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of the
Missouri Botanical Garden

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A Quarterly Journal containing Scientific Contributions from the Missouri Botanical Garden and the Graduate Laboratory of the Henry Shaw School of Botany of Washington University in affiliation with the Missouri Botanical Garden.

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MISSOURI BOTANICAL GARDEN

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Volume XIX Number 1

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JULIUS VON SACHS

Annals
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Vol. 19	FEBRUARY, 1932	No. 1

JULIUS VON SACHS

October 2, 1832—Born at Breslau, Germany.

1845–50—Attended the Gymnasium at Breslau.

1851–56—Student at Karls-Ferdinands Universität, Prag.

1856—Received degree of Doctor of Philosophy from Karls-Ferdinands Universität.

1857–59—Privatdocent at Karls-Ferdinands Universität.

1859–61—Physiological assistant at Agricultural Academy of Tharandt.

1861–67—Professor of Botany and Natural History at Agricultural Academy of Poppelsdorf, near Bonn.

1865—Published 'Handbuch der Experimental-Physiologie der Pflanzen.'

1868—Professor of Botany at University of Freiburg, succeeding De Bary. Published 'Lehrbuch der Botanik.'

1869–97—Professor of Botany, University of Würzburg.

1875—Published 'Geschichte der Botanik.'

May 29, 1897—Died at Würzburg.

LIST OF STUDENTS

First students:

In Bonn—Gregor Kraus

In Freiburg—Millardet

In Würzburg—

Baranetzky	Hansen	Reinke
Bower	Hauptfleisch	D. H. Scott
Brefeld	Klebs	Stahl
Fr. Darwin	J. Loeb	Vines
Detlefsen	H. Müller-Thurgau	deVries
Elfving	Moll	Marshall-Ward
W. Gardiner	Noll	Weber
Godlewski	Pedersen	Wortmann
Goebel	Pfeffer	Zimmermann
	Prantl	

PLANT PHYSIOLOGY AS SACHS FOUND IT[1]

ERNEST S. REYNOLDS

Physiologist to the Missouri Botanical Garden
Associate Professor in the Henry Shaw School of Botany of Washington University

FORMATIVE INFLUENCES

Julius von Sachs, in whose honor this celebration is held, began his work at a strategic time in the development of plant physiology. The foundational sciences of chemistry and physics had emerged from the restraints imposed upon them by the spirit of the Middle Ages and the bases for many of the modern concepts had been laid. Since the development of modern plant physiology was necessarily dependent upon a scientific understanding of the laws of physics and chemistry the best that could be expected of primitive biological studies was an accurate description of the apparent reactions of organisms. Although the ancients, including the most noted of the philosophers, had a modicum of essentially correct concepts of animal physiology, because of the subjective element in human physiology they failed, due to the objective character of plants, in understanding even as much concerning them as they knew of animals. The nutritional dependence of plants upon their environment, together with a realization that some method of transfer of materials in the plant is necessary, the obvious importance of seeds in the continuity of life and certain empirical observations upon apparent values of certain fertilizing materials—these constituted essentially the stock in trade of the ancients. Later, analogies between the better-known activities of animals, especially of the human body, and the supposed reactions of plants resulted in the accumulation of certain hypotheses which, although unsupported by experiments or adequate observation, have in some instances more recently been demonstrated as correct. These, however, were scarcely more than lucky guesses. It is true, nevertheless, that progress in animal physiology has often been of great value in suggesting profitable lines of investigation

[1] A paper read at the celebration held at the Missouri Botanical Garden, December 27, 1931, in honor of the one-hundredth anniversary of the birth of Julius Sachs.

in the physiology of plants. During the history of our science there has been an interesting oscillating from the extreme of the complete dependence upon analogies with animal physiology, of the ancients, to the opposite extreme, as exemplified by Schleiden (1849), who refers to "the fanciful analogy between the physiology of animals and of plants." "In consequence," he continues, "of the use of this absurd analogy, almost all of the works which have hitherto appeared on vegetable physiology are perfectly worthless, for in no instance have they adopted the only true fundamental position, namely, the essential peculiarity of vegetable life." The pendulum was to swing back, due in no small measure to Schleiden's further studies, to a recognition of the essential unity of life, together with a proper regard for its numerous modifications and diversities. Not only did advances in animal physiology aid in establishing a point of view in the study of plants, but two other influences also were of prime importance in giving a proper impetus to the formation of a true science of vegetable physiology.

Developments in general microscopy soon brought more sharply into view the problems of plant structure. Malpighi and Grew, beginning in 1671, illustrated and carefully described much of the tissue structure of plants, although it seems clear that they did not conceive of these organisms as built up of the unit structures now known as "cells"; nor was it until von Mohl, about 1830, a hundred and fifty years later, clearly expounded the proposition that the cell is the unit of structure, that there was a general acceptance of this doctrine. Nevertheless, the exact knowledge of the general anatomy of the stem led to numerous queries as to the utility of the various units to plants. Thus a fairly correct understanding of anatomy stimulated a study of physiology. Malpighi had concluded that the leaves of plants are important in their nutrition, and before that von Helmont's famous experiment with the willow tree had demonstrated the fallacy of the ancient belief that elaborated food from the soil is the chief source of plant substance. Yet as late as the publication of Schleiden's and von Mohl's texts, it was found necessary to controvert vigorously this belief in the absorption of large quantities of organic food from the soil.

Stephen Hales in 1727 published his 'Vegetable Staticks,' and as this was the first considerable attempt to study plant physiological problems by exact measurements it is especially important in examining the bases of the modern science. Among the phenomena studied were transpiration, the pulling action of leaves on the transpiration stream, the reduced pressure in the plant during active transpiration, stump pressures, pressures developed in spring vegetation, the alleged circulation of sap, presence of air in stems, the free passage of water in either direction through the stem when leaves are actively transpiring, and the rate of passage of water upward due to leaf pull contrasted with the downward movement under the weight and pressure of several feet of water. In many of these problems he came to essentially correct conclusions and remained for a hundred years the brightest light in the field of the application of physics to vegetable physiology.

Robert Brown, about 1833, is credited with having discovered and named the cell nucleus, the movement of protoplasm, and most important, from the theoretical physiological aspect, the dancing movement of small particles suspended in liquid which was named for him the Brownian movement.

It is to the rapid development of chemistry, however, that we must look for the main stimulus which finally established plant physiology upon a modern scientific basis. Just before the elimination of the phlogiston theory in chemistry, Priestley (1790), in the course of his studies upon atmospheric gases, published a series of studies upon the relations of plants to the air. Some of the section titles of his work, giving an indication of his contributions to the subject, are as follows:

"Of the Restoration of Air, in which a Candle has burned out by Vegetation."

"Of the Restoration of Air infected with animal Respiration or Putrefaction, by vegetation."

"Of the Growth of Plants in dephlogisticated Air."

"Of the State of Air confined in the bladders of Sea Weed."

"Of the spontaneous Emission of dephlogisticated Air from Water containing a vegetable green Matter."

"Of the Purification of Air by Plants, and the Influence of Light on that Process."

Sachs (1906), in his 'History of Botany,' says: "The establishment of the fact, that parts of plants give off oxygen under certain circumstances, did little or nothing to further the theory of nutrition; and that was all that vegetable physiology owes to Priestley." It seems to the writer, however, that, in view of the above quoted section titles, this dismissal of Priestley with such faint praise is hardly justifiable if one reads carefully his publications. He established the facts that light is essential to the process of giving off oxygen and that in the dark there is definite injury to air, viewed from the point of view of the phlogiston theory. Sachs is further in error when he says later: "Priestley himself did not suspect that the deposit in question, afterwards known as Priestley's matter and found to consist of Algae, was a vegetable substance."[1] He not only "suspected" that it was a "vegetable substance" when he first saw and experimented with it, but in his Section VII definitely states that other scientists better versed in botany had examined it for him and had determined it as a plant; and he finally says he is convinced that it is a plant which reached the jars through its "seeds" either having been in the water to begin with or, floating in the air, had entered due to loose stoppers. He criticized Ingen-Housz even for hypothesizing a spontaneous generation of the plant, rather than accepting the origin through outside infection.

Ingen-Housz (1779), however, published a much more extended study of the whole problem in his 'Experiments upon Vegetables' in which he demonstrated the use of carbon dioxide as the source of carbon for plant nutrition, and the relation of light and the green color of plants to the process. He also stated clearly that atmospheric oxygen is necessary for continued life in plants. Senebier (1800), and especially de Saussure (1804), added much to the preciseness of the chemical demonstrations of the relationship of plant nutrition to carbon dioxide and water and of respiration to the atmospheric gases. Studies of the mineral content of plants and of the source of the nitrogen used by plants completed a reasonable chemical foundation on which new advances could be built. However, much of this new material was either not accepted or at any rate had not become generally

[1] Sachs seems not to have referred to Priestley's publication of 1790.

diffused among botanists until the beginning of Sachs's investigations.

The Status of Plant Physiology in 1850

With this brief review of the main sources of stimulation for the establishment of a science of plant physiology we may now turn more particularly to the status of the subject when Sachs appeared in the field. It is convenient to select the year 1850 as approximately the end of the pre-Sachs period, especially because at about this time von Mohl (1852) published his 'Principles of the Anatomy and Physiology of the Vegetable Cell,' which indicates especially well the status of the subject at that period. A short time before this Schleiden's (1843) 'Grundzüge der Wissenschaftlichen Botanik' had appeared, and this also presents a picture somewhat different from von Mohl's summary. The term "protoplasm" had just been accepted, but there was no clear understanding of the usual process of cell formation, as is indicated in this statement by Schleiden (1849): "The process of the reproduction of cells by the formation of new cells in their interior is a general law in the vegetable kingdom and is the foundation of the production of cell-tissue." Nevertheless, the importance of a clear understanding of the process was clearly recognized in his further statement that "The question respecting the multiplication of the cells consequently includes the origin and the life of the whole plant, which remains altogether obscure to us previous to the elucidation of this relation."

The group of catalysts had been recognized and named by chemists; and the general catalytic action of the "slime" or "protoplasm" had been discovered. These observations led finally to the recognition of specific catalytic action in plants. Thus Payen and Persoz in 1833 had named diastase and had cleared up some of the earlier misunderstandings concerning the changing of starch to sugar; and Liebig and Wöhler had recognized and named emulsin in 1837 as a substance acting upon amygdalin. Still the significance of these enzymes as representatives of a class of substances was not appreciated, and the conditions governing their activities were not well understood. Nevertheless, a few foundation stones for a study of enzyme chemistry had been laid.

Following the early observations by Nollet and others, Dutrochet, about 1830, developed the concept of endosmosis as an explanation of absorption by the plant, and thereafter a general extension of the theory of endosmosis offered an explanation of the passage of water from cell to cell throughout the parenchyma tissues. However, no careful quantitative determinations of pressures were made and the theories were vague. Thus von Mohl (1852) says: "Since the discovery of endosmose, most vegetable physiologists have assumed it as an axiom that the absorption by cells depends wholly and solely upon the laws of endosmose, none of the peculiar forces of the living cell co-operating. All the conditions to bring about strong endosmosis do really exist in the living vegetable cell, namely, a membrane freely penetrable by watery fluids; on the one side of this the cell-sap which contains proteine substances, dextrine, sugar, etc., in solution, on the other side the water occurring in nature, in the state of an extremely diluted saline solution. This renders it readily explicable how cells which are laid in water swell up rapidly, in many cases, if they contain a concentrated protoplasm and have not firm walls (e.g., many pollen-grains), the powerful absorption of water causing them to burst; and how, on the other hand, if they are laid in a strong solution of sugar, gum, etc., they become emptied and collapse. Under these circumstances, the assumption that the absorption of the cells will be regulated by the laws of endosmose, is fully justified, yet special proofs of this can only be partially advanced, because on one side the phenomena of absorption are too little known in many respects, and on the other side the theory of endosmose is not yet perfect enough to allow of our making out in all cases the share it has in any given phenomenon." The limitations of the term "endosmosis" were not clear and even yet there is a lack of clarity in the usage of terms and the concepts included. For example, osmosis is sometimes still made to include the passage of both solute and solvent through the membrane, which at that time was believed to be the cell wall, although there are obvious advantages in restricting the term to the diffusion of the solvent and thus recognizing the process as a special case of diffusion in which pressures are developed and maintained. The diffusion of

solutes then falls into its place as an example of the general process.

The universal solvent action of water for all substances, including gases, entering the plant was well recognized. Quantitative determinations of the mineral content of plants had been made, which indicated the relatively small quantities necessary and the range of salts usually present. These data had also indicated a problem less easily explained, however, namely, why several kinds of plants living upon the same soil may accumulate different proportions of the various soil solutes. Liebig's hypothesis of excretion was offered by him to account for this phenomenon by assuming no differential permeability but a subsequent excretion of supposedly toxic mineral substances. Later, the experiments of others indicated differential absorption.

The problem of transportation in the plant was in an active state of discussion. The older vegetable anatomists, Malpighi and Grew, had studied the vascular system and described the elongated tubes as "tracheae" which, so far as they could detect, always contained air. Others, through unconvincing experiments, had stated that these tubes were the water-conducting channels. Schleiden (1849), in various portions of his 'Principles,' called attention to the incomplete nature of the evidence, and his conclusions are clearly indicated thus, "That the vessels convey only air, and no juices, may be seen by any one possessing the least physical knowledge, on the most cursory glance at a longitudinal section of a plant"; and again, "The so-called vessels in most plants never convey sap; and with others it is probable that they convey it only during a few weeks while the new buds are forming." He inclined toward the belief that all transfer of fluid in plants was from cell to cell by some osmotic process, but admitted a possibility that at certain seasons of the year in some plants, or under pathologic conditions, sap might pass into and possibly through the fully formed tracheae.

An example of the necessity of a clear differentiation between the solute and the solvent in discussing the subject of sap transfer is seen in the following statement from von Mohl (1852): "All these explanations of the movement of the sap bear reference only

to its ascent, not one of them applies at all to the descent of the elaborated sap. If the bark and the cambium layer attract the nutrient matter from the leaves because their cells contain a more concentrated sap than the cells of the leaves, it is not evident why they cannot draw the sap directly from the root and the wood, instead of by the long circuit through the leaves, and why the bark is wholly incapable of carrying sap upwards." It must be remembered that von Mohl in 1852 was inclined to believe that the passage of water upward must be in the parenchyma cells of the wood by the power of endosmosis induced by transpiration from the foliage, and that there is a corresponding down stream in the bark. In the above quotation, then, there would have been no special problem had he clearly discerned that, on the basis of diffusion, the passage of solutes from cell to cell must be from regions of greater to those of lesser concentrations and that they must move independently of the direction of the solvent.

Transpiration is one of the activities of plants which was recognized by early observers and studied somewhat thoroughly by Hales. The rates and total amounts of water loss were determined for a fair range of representative plants and environments so that the essential unity of transpiration and physical evaporation had been accepted. Schleiden believed that transpiration by concentrating the sap in the leaf cells caused a progressive concentration of sap downward and thus furnished, together with the osmotic action of cells, an adequate explanation of the passage of liquids upward. Guttation was known in some cases and the specialized structures through which it takes place had been studied carefully.

The more common of the mineral elements which are considered as essential to plant growth had been studied; and considerable knowledge of specific chemical compounds from plants had accumulated. The uniformity of certain types of compounds, especially of sugar-like nature, had suggested some nutritional importance for them. The four classes of compounds, carbohydrates, not yet so named, organic acids, oils, and proteins had been distinguished.

As already indicated, the essential outline of photosynthesis

had been drawn but not all of the demonstrations had been fully accepted, and the term respiration still frequently included all gaseous exchanges by plants although von Mohl pointed out the desirability of using it in the restricted sense used in animal physiology.

Ammonia and its salts supplied through the roots appeared to be the main if not sole source of nitrogen, while the free nitrogen of the atmosphere had been ruled out of consideration by the work of several investigators. Although it was considerably later that the nitrifying power of soil organisms was offered as an explanation of the renewal of nitrogen in the soil, and it was believed that the continuous supply of nitrogen for plants was through the ammonia of the atmosphere, still some believed in a slow automatic ammonification in the soil.

The curious milk-sap theory of Schultz (1823–41) is an example of the extremes to which a theorist may go. He supposed that milk-sap was the exact analogue of the blood of animals and claimed that circulation, coagulation, and blood corpuscles were all duplicated in the phenomena which he observed in the milk tubes. This concept was sufficiently important for von Mohl to devote considerable time and argument to demonstrate its fallacies. Schleiden, in a characteristic passage, thus disposes of the older work: "On the subject of these structures, and especially the milk-vessels, I am rather afraid of saying too much than too little, for owing to the total neglect of a correct, scientific method and the purile sporting with hypotheses, without any foundation or guiding principle, the question respecting them is loaded with such a heap of nonsense that the best way in beginning upon it is, in the first place, to throw overboard all that has hitherto been done and commence entirely *de novo*, instead of undertaking the thankless task of cleansing this true Augean stable." The obvious nutritional difference between fungi and green plants had been studied experimentally to some extent from the time when it was demonstrated that the fungi did not absorb carbon dioxide in the light.

An interesting concept of Schleiden concerns the place in which elaboration of the nutritional substances occurs. He believed that the water and its inorganic salts and other necessary sub-

stances become elaborated in each cell so that, as he remarked, "nothing remains for the leaves to assimilate." Thus it was not necessary to have a means of transfer of food substances from the leaves to other parts of the plant and he denied any downward flow of sap in the bark. He appears to have believed that the carbon dioxide absorbed by leaves is conducted through the internal atmosphere to all parts of plants. Thus he says, "The conclusion that the carbonic acid found in the leaves is consumed by them is about as rational as the inference would be, from the respiratory movements of the nose and mouth, that the brain performed the functions of the lungs."

Schleiden lists as one of the main problems of seed germination: "An accurate determination of the degree of heat present during germination and a comparison of the same with the quantities of carbon and hydrogen which are consumed." Von Mohl clearly indicated the rapid loss of sensitivity and subsequent early death of plants cut off from an oxygen supply, thus calling attention to the close analogy between animal respiration and that of plants. The heat produced by plants was directly associated with the respirational process. The modern interpretations of gaseous exchanges between the plant and the atmosphere were not fully accepted at this time although it was known that carbon dioxide provides the carbon supply for green plants. Schleiden, however, stated in 1849 that, "It would appear that the exhalation of oxygen and the absorption of carbonic acid gas never stand in immediate relation with each other," and he saw in the exhalation of carbon dioxide only the beginning of decay. On the other hand, von Mohl, in his 'Anatomy and Physiology of the Vegetable Cell' published in 1852 clearly distinguished between the nutritive and the respirational processes involving the atmospheric gases.

A "fermentation-fungus" had been discovered and it had been suggested as the cause of the process of fermentation, but there was still no clear recognition of the essential nature of the yeast organism and its relation to the fermentation process.

The three main phases of the growth process, cell formation, cell enlargement, and cell differentiation, had been distinguished, but the details of these processes had yet to be filled in.

Due to the almost slavish adherence to the doctrine that all processes in animals must find their exact equivalent in plants, efforts were constantly made to demonstrate a method of excretion which would rid plants of injurious substances. Liebig believed that this was accomplished through the roots, at least to a considerable degree. Others, as, for example, von Mohl, pointed out that no experimental data had been adduced to provide for any but insignificant quantities of substances. A doctrine at that time which was used to uphold the excretion hypothesis taught that there must be an exosmosis to balance the endosmosis, and this then in the roots resulted in excretion of injurious materials. There had arisen at this time also a suggestion that toxic root excretions or the decayed remains of plants poison the soil for the plants producing them. While no experimental data were available the observations on crops had made this soil toxin hypothesis seem probable.

Schleiden's theory of the organization of the embryo from the tip of the pollen tube had just been displaced by the careful studies of Amici and Hoffmeister demonstrating the presence of the egg-cell in the embryo sac and the fertilizing action of the pollen tube. Sperms had been seen in the Cryptogams, and the essential features of the fertilizing process had been well described by several investigators.

Geotropism was on the verge of being discovered, for Knight's work had already been published, demonstrating reaction to centrifugal force, yet as late as Schleiden's 'Principles' it is stated that, "We know nothing at all respecting the cause of the direction taken by the germinating plant" and the action of gravitation as a stimulus was not accepted. The directional action of light on the stem was recognized, and the "sleep" reaction of many leaves was a well-known phenomenon. However, Sir Humphrey Davy, in his 'Elements of Agricultural Chemistry,' as late as 1813, had denied the concept of irritability in plants.

Controversies at this period were numerous, due to preconceived notions, inaccurate observations, and misinterpretations. While in the main Schleiden was a progressive scientist, there were several problems in which, because he took the cautious,

conservative attitude, he failed to espouse the new and correct ideas. While his criticisms of his predecessors are often severe and he often places little reliance on their work, this attitude seems to be due largely to his keen appreciation of the necessity of controlled experiments and of accurate and frequently repeated observations. One other source of his strictures was his repudiation of the popular method of almost complete dependence upon analogies between plants and animals. Although his extreme attitude was finally to be overthrown yet no doubt he was correct in believing at that time that these analogies were too easily accepted without adequate scientific evidence.

It is clear then that at the beginning of Sachs's activity the general outlines of our new plant physiology had been developed, but many of the major concepts were still seriously questioned while many important details and some major fields needed careful experimental study. Moreover, the separation of this field of investigation from that of general botanical studies had not taken place.

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THE CONTRIBUTIONS TO BOTANY OF JULIUS VON SACHS[1]

CHARLES F. HOTTES

Professor of Plant Physiology, University of Illinois

Director Moore has very wisely divided the programme into three epochs,—Plant Physiology as Sachs Found It, The Contributions of Sachs to Plant Physiology, and Progress in Plant Physiology since Sachs. By this plan an opportunity is given the several speakers of presenting to their listeners a true perspective of the field under consideration, and of the position and influence therein of Sachs, its central figure. The first epoch we have had already passed before us, and I feel certain all have been impressed with the slow advance of physiology and of botany until approximately the middle of the nineteenth century, when, with new methods and directive thought so essential to real progress, a new era was ushered in. In this era Julius von Sachs was to play a most important rôle.

In presenting the contributions which Sachs has made, I feel that full justice cannot be done him should I confine my remarks strictly to physiology. One of his most far-reaching and lasting contributions was the masterly manner in which he coördinated the several fields of botany, and made the *functional* plant the unit of interest. This he did in his 'Lehrbuch,' first edition, 1868.

The status of botany, particularly in America and England, at that period was deplorable. The few bold spirits that ventured into the botanic field were compelled to make their way to Germany to sit as disciples at the feet of the great masters,—De Bary, Sachs, Strasburger, etc., successors or contemporaries of Schleiden, von Mohl and Hofmeister. To this galaxy of investigators, largely in the period from 1840 to 1880, we owe the most distinctive discoveries and advances in the history of botany, and to the genius of Sachs, the organization of these into a new and virile botany. When I seem to digress from the more limited subject assigned me and speak of the contributions that Sachs

[1] A paper read at the celebration held at the Missouri Botanical Garden, December 27, 1931, in honor of the one-hundredth anniversary of the birth of Julius Sachs.

made to the field of botany as a whole, I do so to emphasize the part the physiology under his leadership has played in it, and the masterful manner in which he welded the heterogeneous fragments of independent research into a real science of botany with all its branches definitely interrelated. In other words, he gave us for the first time a text-book in which the plant as a *functional machine* is lucidly and accurately brought before the student. Furthermore, to him, more than to any other contributor to the field of botany, do we owe the deep significance of the physiological division of labor in the interpretation of anatomic and morphologic structure.

For a proper appreciation of the conditions then (1868) prevailing in the field of botany, and the influence of Sachs in the molding of future progress, I cannot do better than to have former students of Sachs, men with whom a number of us have or had personal acquaintance, speak to us with their accustomed accuracy and freshness.

Farlow, in his presidential address before the Botanical Society, Cleveland, 1913, says:

"In the laboratory [De Bary's], I noticed that the students seemed to refer frequently to a book of which I had never seen a copy or even heard. The book was Sachs's 'Lehrbuch,' second edition, 1870. I bought the book and was perfectly amazed. I had never dreamed that botany covered so large a field. The 'Lehrbuch' was an admirable summary of what was known of all departments of botany up to that date, well written and excellently illustrated. The fourth edition, which appeared while I was in Strassburg, was still better. On looking at the second edition a number of years later, I noticed what seemed to be a curious omission. No mention whatever was made of bacteria. In the fourth edition they are mentioned under *Schizomycetes*. The absence of reference to bacteria in the earlier edition, however, was not an omission. There were no bacteria until Cohn published his 'Untersuchungen über Bacterien' in 1872. The fact that forty years ago Sachs had never heard of bacteria, while to-day life has almost become a burden, one hears so much about them, is a striking instance of the rapidity of development of a subject having a practical as well as a theoretical value. I know no single book which has had so great an influence in shaping the course of modern botany as Sachs's 'Lehrbuch.' It may be that the facts there given were generally known in Germany, but they were not known in other countries. On returning home by way of England in 1874, I showed my copy of Sachs to several English botanists and it was evident that it was quite new to them. It was certainly unknown in America. If imitation is the sincerest flattery, the value of Sachs's 'Lehrbuch' was quickly recognized, for, using it as a model or basis, there soon appeared a large number of really excellent textbooks in various languages in which one recognized Sachs translated, Sachs con-

densed, Sachs diluted, Sachs trimmed to suit local demands. Publishers, were they capable of gratitude, would have erected a monument to Sachs's memory long ago. Draughtsmen, on the other hand, had little reason to bless his memory. Even now we can hardly open a new text-book without seeing the inevitable 'after Sachs.' "

From this brief extract you will note the status of botany in America in 1870. Let us next turn to England and hear in turn from Vines, Scott, and Bower an expression of the condition of botany in that country in the middle of the decade, and an appreciation of Sachs as lecturer and teacher, and of his great influence in molding and directing a new and lasting trend in botanic teaching and investigation,—a trend that has gained in impetus with a younger and better-trained generation all too frequently innocently ignorant, I am sorry to say, of a debt it owes to him to whom we this day in gratitude pay homage and tribute.

Quoting from Vines:

"In 1876 I had been appointed an Assistant Tutor at Christ's College, Cambridge, for the benefit of the increasing number of the undergraduates who were reading Natural Science, and had begun to lecture there on Botany, though I had no means for carrying on any practical work. . .

"It seemed to me, therefore, essential to equip myself further for future work by spending what time I could spare in some well-known laboratory. As such equipment was quite unobtainable in Britain, my thoughts turned naturally to Germany. Then arose the question of to which laboratory I should visit. At that time the best known of the German botanists, other than systematists, was Hofmeister, though his doctrine of 'alternation of generations' was still regarded with some suspicion by those of the more orthodox British botanists who knew anything about it; had he been still at work, I should probably have gone to him at Tübingen, but he had quite recently died. Considering that the greater part of my botanical lore had been derived from his immortal *Lehrbuch* (3rd ed. 1874), I had no hesitation in deciding that I must go to Julius Sachs at Würzburg, who was then at the zenith of his activity and fame, and whose laboratory was renowned for its physiological work. Having obtained leave of absence for the Easter Term from the College authorities, and armed with an introduction from Mr. Thiselton-Dyer, I accordingly set out for Würzburg in March, 1877. . .

"On beginning work in the laboratory, I found myself to be the only advanced student, so that I had the great advantage of the undivided attention of the Professor, which I gratefully acknowledge was ungrudgingly bestowed. The special subject of study suggested to me was that of growth, especially in its relation to light, and Sachs placed at my disposal and demonstrated to me all the available apparatus for measurement. Such was my first introduction to practical plant-physiology.

"Naturally I saw a good deal of the Professor in those early days, and an acquaintanceship developed into an intimacy which continued unbroken until his death in 1897. I often accompanied him for a stroll round the Botanic Garden

or in the shady avenues of the town, when he won my admiration by his remarkable conversational gift, discoursing of many things, not always botanical by any means, but ranging widely to include such topics as the philosophy of Herbert Spencer or the works of Lecky. . .

"He was then engaged upon his experiments, by the lithium-method, on the rate of the transpiration-current, in which I occasionally helped him and had the opportunity of observing the precision and skill with which he devised and carried them out. . .

* * * * * * * *

"Accordingly I returned to Würzburg in April, and found the laboratory much as I had left it three years before. But the 'Assistant' was now Dr. Goebel (in after years Professor of Botany at Munich). . .

"Professor Sachs was as friendly and energetic as ever, though I did not see so much of him as in 1877, for he was engaged not so much in experimental work as in the preparation of his remarkable papers on 'Stoff und Form der Pflanzenorgane.'

"I did not, on this occasion, undertake any definite piece of work, but continued the investigation of the chemical composition of aleurone on which I had been engaged off and on for some time, in which the Professor took a lively interest as it was a subject to which he had not devoted much attention. . .

"But the outstanding feature of the Semester was the Professor's course of demonstration-lectures on plant-physiology. The lectures were given on Saturday mornings, and each lasted for about two hours. Here Sachs was at his very best, inspired by enthusiasm for his subject which he did not fail to communicate to his audience. The eloquent speech; the pictorial illustration, generally by means of large sheets of white paper and a stick of charcoal instead of black-board and chalk; the manipulative dexterity; all these combined to rivet attention. . .

"Such is my story, but it would be incomplete were I to conclude without some moral reflections. The first and most obvious is—how simple, we should now call them inadequate, were the means with which the great advances in botanical science, between 1840 and 1880, were achieved in Germany! Clearly great epoch-making discoveries do not depend upon huge superlatively equipped laboratories; it is the man, not the mechanism, that counts. The next takes the form of the question—was it worth while to go to Germany to study? My answer is a strong affirmative. Brief and fragmentary as were my studies there, I recognise how great was their advantage to me, and I do not forget the debt of gratitude that I owe to the Professors who so kindly received and helped me. If the enquiry be pressed further—what was it that I gained? my answer is that I gained, not so much actual knowledge as what, for lack of a better term, I must call inspiration, the right point of view; in fact, a sort of botanical 'confirmation' at the hands of the pontiffs of the science. To make my meaning clear, I may explain that though I had read much of what there was to read on plant physiology (it was relatively little in 1877!), I had had no opportunity of comparing notes with another plant-physiologist until I went to Sachs, the fountain-head of so much of the knowledge which I had laboriously gleaned from books. His expositions of his own work, and his criticisms on the works of others, including my own, were a liberal education. I sought and found in Germany what was unobtainable in my own country."

Ten years following the experiences related by Farlow we find Scott (1880–82), upon the advice and support of Thiselton-Dyer and Vines, a student in the laboratory at Würzburg. He tells us:

"At that time, Sachs had a high reputation in England, owing, in a great degree, to his famous Text-book, of which an English edition, translated by Bennett and Thiselton-Dyer, had already appeared in 1875. This had a marked influence on the progress of Botany in England. . .

"Sachs was the best lecturer I ever heard. Hard work at German, before starting from England, had prepared me to understand what I heard without much effort. The lectures were extraordinarily clear, interesting, and sometimes amusing. . .

"The brilliancy of Sachs's lectures was enhanced by the beauty of the sketches which he made to illustrate them. Usually these were on the blackboard, but when any specially elaborate structure was to be shown, a sheet of cartridge-paper was brought in, and Sachs made, before our eyes, a finished chalk drawing in colours—truly a wonderful performance. Later in the season Sachs started his physiology lectures, given on Saturdays. In this case, as experiments had to be demonstrated, two hours (actually one and three quarters) were allowed. Though I was never attracted to physiology, it was a great experience to witness these expositions by the greatest plant-physiologist of his time. . .

"Late in July, as the result of a conference with Sachs and Goebel, I decided to work for the Ph.D. At that time the subject proposed for my dissertation was the relation between leaf and branch. . .

"On returning to Würzburg after the long vacation, I found that Sachs had changed his mind; he no longer thought the morphological subject suitable. Such questions, he said, were not so much thought of in England as in Germany. I had never taken much to the plan myself, and was relieved when Sachs advised me to transfer my energies to a purely anatomical investigation—the development of articulated laticiferous vessels. This eventually formed the subject of my dissertation.

"At that time the development of laticiferous tubes in general was not so well understood as it is now; in particular, the origin of the articulated type by cell-fusion was not finally established. This was the problem which I was to help in solving."

We have heard from Farlow, a student of cryptogamic botany; from Vines, a student of plant physiology; from Scott, a student of paleobotany; and, finally, we shall hear from Bower, a student of morphologic botany, whose noteworthy contributions in that field no doubt have been influenced by his contact with Sachs. Bower says:

"Within a few years of Hofmeister's 'Vergleichende Untersuchungen' (1851) came the 'Origin of Species' (1859). It then appeared as though a theory of evolution had merely to adopt the results already demonstrated by him. After events so stirring we need not be surprised that a pause should follow. It took time for men to realise the bearings of the new views, and still more to convert them into action. Botanically little change appeared immediately in Britain;

but within a decade an event happened in Germany which was to produce far-reaching results. It was the publication of the *Text-book* by Sachs.

"That work was written with consummate judgment, and illustrated with all the skill of a trained draftsman, who was also a keen observer. Sachs was, I believe, the son of a wood-cut artist, and had been himself trained as such. But beyond his keen vision and artistic touch, he possessed also a philosophical outlook combined with keen receptivity. These faculties made him the best possible exponent of the results of those, such as Hofmeister, whose powers of exposition were less than his own. Little wonder that the *Text-book*, which embodied not only their results but also a vast extent of Sachs' own observations, morphological and physiological, had a phenomenal success. The first English edition published in 1875 was based upon the third and fourth German editions, and it fell into my hands at once on its appearance. It came as a revelation to the group of enthusiasts beginning to gather round Vines at Cambridge, and supplied the text upon which much of our work was based. We felt then that we were daily seeing things not, it was true, new to science, but at least observed for the first time in Britain. Some of us, however, naturally looked further to the living source; and when Vines went to Würzburg in 1877, though still an undergraduate I joined him for some weeks in the summer, to sit at the feet of Sachs himself. .

"Looking back upon this period of preparation, there is no doubt that it was necessary at the time that some of us should become personally acquainted with German laboratories and methods. Going to foreign schools was the readiest way of making up that backwardness which had resulted from the academic apathy of a generation of the teaching botanists of Britain, and from their failure to keep pace with those advances in observation and laboratory technique which had grown up on the continent. . .

"It is for those who direct the progress of the teaching of the science to take care that they shall not, by allowing too early specialisation along applied channels, send out specialists too quickly and imperfectly qualified. But the more grave risk is that they should allow the central institutions to lose again their hold upon the broad stream of pure science, as their predecessors did at the middle of the last century, by over-concentration upon special requirements."

From the extracts that I have read, it is very evident that the contributions of Schleiden, von Mohl, Hofmeister, De Bary, Naegeli, Sachs, and others, made during the middle decades (1840–1880) of the nineteenth century, and which marks that period the most notable in the history of botany, had little affected the trend of botany in America or England. It was the publication of Sachs' 'Lehrbuch' in 1868, and especially the translation of a later edition into English, that proved the most potent factor in the development of botany in English-speaking countries.

The 'Lehrbuch' owed its unprecedented popularity and success to: (1) the fact that in it for the first time the widely scattered and, in many instances uncorrelated, discoveries of Sachs' predecessors and contemporaries were skillfully coördinated with his own, and

presented in a lucid, attractive style, and illustrated with figures that to this day are unsurpassed; to (2) the plan well-nigh faultless in conception and execution, in which the well-balanced treatment of the subject matter is interwoven with theories, critique, suggestive problems, and prospective lines of research; and finally, to (3) the revolutionary, I am tempted to say, treatment by which the whole of botany from cell through tissues, taxonomy, morphology, anatomy, ontogeny, and phylogeny, and the origin of species through the Doctrine of Descent, receive thoughtful consideration and masterful coördination. Throughout the book one is impressed with the persistence with which a single motive, namely, *function*, pervades and dominates the whole, and reveals to the thoughtful reader the inner workings of a great mind. In fact that seemed to have been his aim and endeavor, for we read in the preface of his Lectures as follows,—"It is not only the right but also the duty of anyone who lectures, however, to place in the foreground his own mode of viewing the matter; the audience wish to know and should know how the science as a whole shaped itself in the mind of the lecturer, and it's comparatively unimportant whether others think the same or otherwise."

Sachs, by placing emphasis on the significance of response, brought to the front the importance of the *protoplasm* of the cell as the responsive material possessed with innate developmental and adaptive potencies, and this point of view was in no small measure responsible for the change in the method and outlook of anatomy, morphology, and taxonomy. It is from this conception only, he maintained, that the origin and persistence of the great groups of the Plant Kingdom can be explained. In like manner it was the environment acting on the responsive protoplasm that brought on physiological division of labor, and with it, differentiation. This was in direct conflict with the phylogenetic view held by the morphologists and anatomists of his time, and, despite the strong criticisms of De Bary in his attempt to uphold the classification of tissues based on the history of development, the physiologic classification into epidermal, fibrovascular, and fundamental, all derived from meristem, prevailed.

Perhaps his deepest philosophic efforts were concentrated on

the finding of an hypothesis that should be helpful in the elucidation of differentiation and organ formation, and the effects of the environment on the same. In a series of contributions on 'Stoff und Form der Pflanzenorgane,' Sachs calls our attention to the impossibility of a formal morphology such as then prevailed, interpreting the significance of organs in any other manner than "als für sich Existirendes, unabhängig von jeder materiellen Grundlage angesehn." In his attempt to formulate a causal relationship between the development of an organ and its function, which he found impossible experimentally to demonstrate, he gave to us an hypothesis, which Loeb, writing in 1906, states is the "only scientific hypothesis of morphogenesis which we thus far possess." In this hypothesis, Sachs maintains that the only adequate explanation for the formation of new organs, of flowers, or of the regenerative processes must be sought in plastic materials, as yet unknown, and produced in the living protoplasm. These "formative stuffs" present in extreme small quantity, on reaching an organ, direct its growth and development in a specific manner. I need not proceed further along this line for I believe it perfectly evident that our modern conceptions of "growth-promoting," "growth-inhibiting," auxamones, yes, even hormones, are rooted in this hypothesis.

In like manner the developmental process proceeding from the egg finds here its only explanation. It is interesting to note the parallelism of expression used by Wilson in the last edition of his 'The Cell in Development and Heredity,' and by Sachs more than fifty years previously. Wilson says:

"That a single cell can carry the total heritage of the complex adult, that it can in the course of a few days or weeks give rise to a mollusc or a man, is one of the marvels of nature. In attempting to attack the problems here involved we must from the outset hold fast to the fact that the specific formative energy of the germ is not impressed upon it from without, but is somehow determined by an internal organization, inherent in the egg and handed on intact from one generation to another by cell-division. Precisely what this organization is we do not know. We do know that it is a heritage from the past somehow perpetuated by cell-division, and that development is only a further extension of processes that have been going on since life began."

I follow, quoting from Sachs:

"So wenig wie die ungeschlechtliche Fortpflanzung ist auch die sexuelle dazu berufen, im strengsten Sinn des Wortes einen neuen Organismus zu produziren;

die Elemente, aus denen dieser entsteht, sind selbst nur Produkte der embryonalen Substanz einer früheren Pflanze und schliesslich können wir sagen: *das was sich seit dem Beginn des organischen Lebens auf der Erde kontinuirlich immerfort in dem ewigen Wechsel aller Gestaltungen, in dem beständigen Wechsel von Leben und Tod lebendig erhalten und sich immerfort regenerirt hat, das ist die embryonale Substanz der Vegetationspunkte, die in bestimmten Fällen sich in männliche und weibliche differenzirt, um sich dann wieder zu vereinigen.* In diesen winzig kleinen Stoffmassen hat sich das organische Leben in dem langwierigen Verlauf der geologischen Epochen beständig selbst erhalten; diejenigen Thiele der Pflanzen, welche sich dem Auge unmittelbar darbieten, die ausgewachsenen Wurzeln, Sprossachsen, Blätter, die Holzmassen u. s. w., dies alles sind Produkte jener embryonalen Substanz, die sich beständig regenerirt, während diese ihre Produkte zwar an Masse millionenfach sie überwiegen, aber keiner Regeneration fähig sind; sie sind es nicht, in denen sich die Kontinuität des organischen Lebens erhält, aber sie sind es, die durch ihre gemeinsame Arbeit den Assimilationsprozess und den Stoffwechsel hervorrufen und ein sehr kleines Quantum der Substanz, die sie zu ihrem Wachsthum nicht selbst verbrauchen, wird zur Ernährung der embryonalen Substanz der Vegetationspunkte und Sexualzellen benutzt."

The two quotations taken from authorities separated by two generations in time show how well Sachs had conceived and developed these problems so fresh and fundamental to biologic thought of to-day.

Further, it is of interest to note that in the above quotation we find the idea of the continuity of the embryonic substance beautifully and unmistakably expressed three years before Weismann gave to us 'Die Kontinuität des Keimplasmas,' destined to exert such a tremendous influence on the biology of the latter part of the nineteenth century.

Continuing along the line of his studies on embryonic tissue, we find in his 'Ueber Wachsthumsperioden und Bildungsreize' a mass of material worthy of the deepest reflection by present-day physiologists. Time and space permit me to cite only two paragraphs, which, however, seem to me to express the key-note to effective physiologic experimentation with plants:

"Durch den in den Pflanze thätigen Gestaltungstrieb wird jedes sich entwickelnde und wachsende Organ, selbst jeder Theil eines solchen, in seiner äusseren Form und seiner inneren Struktur fortschreitend verändert: das Organ ist heute nicht mehr dasselbe Ding wie gestern und wird morgen wieder ein Ding mit anderen Eigenschaften sein, selbst wenn man dies an der äusseren Form und der mikroskopischen Struktur nicht wahrnimmt.

"Wird nun das sich entwickelnde, wachsende Organ von äusseren Einwirkungen betroffen, welche die Art seines Wachsthums verändern, so muss diese Reaction verschieden ausfallen, je nachdem die gleiche äussere Einwirkung das wachsende Organ gestern, heute oder morgen trifft."

I feel confident that the discordant results with the use of similar organisms now so frequently reported may be greatly lessened through a more conscientious study of the principles suggested in the above quotation. The physiological phase of development at the time of experimentation, and a more detailed attention to the environmental factors to which the plant is exposed preceding the experiment, should receive the same serious attention now as then.

Proceeding from these philosophic aspects of the meristem or growing tip, I may pass to a brief consideration of his views on cell activity and cell relation. Because of his strong bias, and consistent with his view concerning the developmental process, Sachs took the position very effectively described by Hertwig as follows:

> "Although from the point of view of the morphologist it has become more and more imperative to regard the cell as the unit of the higher organism, still, from the physiological point of view, the higher organisms must be regarded as masses of material of structural parts subordinate in function to the whole, and displaying only a limited division of capacities. And so the cell theory, according to which the cell was exalted unduly as the unit of life, the center of life, the elementary organism, must take limitation and correction from these wider views."

With the emphasis placed on the organism rather than on the cell, Sachs clearly saw that the complex of tissue cells in the plant, encased as they are in cellulose walls, must have some provision by which the whole is organized into an interacting community and suspected protoplasmic connections long before their actual demonstration. In a series of articles under the general head 'Beziehungungen zwischen Zellbildung und Wachsthum,' he makes clear his ideas on the relation between growth and cell-division, and insists that growth is primary and cell-division secondary. Here he also develops his principles of cell-division as (1) cells divide into equal parts, and (2) each new plane of division intersects at right angles the previous one, subsequently elaborated by Hertwig. His elaborate studies on the geometrical relations of cleavage-planes in growing plant tissues which are either anticlinal or periclinal, received much attention and are not without interest to-day. He was the first to call our attention to the relation between size of cell and size of organism.

I shall next pass to the consideration of the more important

contributions in experimental physiology contributed by Sachs, and on which the superstructure of present-day physiology was built. The task of presenting the gist of one hundred papers is not an easy one, and time does not permit of great detail. I shall therefore confine myself to brief remarks concerning those researches that, in my opinion, were most important in the development of experimental physiology of which he is the recognized founder, and as my guide I shall, in general, follow the headings as given in his 'Gesammelte Abhandlungen.'

In the first section, "Ueber Wärmewirkungen an Pflanzen," we find several contributions of present-day interest. His studies on crystal formation in the freezing of plant tissue corrected false conclusions that had been previously held, but he was unfortunate in his explanation of the cause of death. His studies on "Vorübergehende Starre-Zustände" (1863) furnished us new and detailed information regarding heat and cold rigor, and gave us the terms phototonus and thermotonus. Here as elsewhere in his discussions on response he says that "irritability both in the vegetable and animal kingdom must in the main be full of purpose." The use of the word purpose has misled many botanists. They not infrequently have accused him of having marked teleological views. This, I believe to be wrong, and a careful reading of his contributions will, I think, correct such an impression. A single quotation from Sachs will make this clear:—"But the fact that, formerly, purpose in the mechanism of organisms was referred to causes other than now, is no reason for robbing our language of a pregnant term. By the expression, This or That mechanism has a purpose in an organism, one understands really nothing more than that this contributes to the ability of the organism to exist." In his studies on germination as affected by temperature, and of maximal temperatures on vegetation, he presents a wealth of information obtained by experimental methods which was new and stimulating then, and to which we even now return. In these papers the terms minimum, optimum, and maximum as the cardinal points were for the first time employed, and the effects of supra temperatures on the several cell functions, for example, turgor and permeability, permanently established. Mention should also be made here of the effects of

minimal temperatures required for chlorophyll formation, even in the gymnosperms where ordinarily chlorophyll forms in the dark.

The second section, "Ueber Licht-Wirkungen an Pflanzen," deals with the transmission of light through plant structures, and brings into use the diaphanoscope revealing the change in the transmitted light due to chlorophyll absorption; with the morphogenic influence of light on the growth, unfolding, etc., of the several plant organs; with the action of colored lights on plants in which his chief object was to determine experimentally the similarity or dissimilarity between the action of different lights on the chlorophyll formation and gas evolution in plants and on silver chloride. In the same paper he investigated chlorophyll formation and tropic response in blue and orange light,—double-walled bell jars—and the disintegrating action of this light on a chlorophyll solution.

The third section, "Ueber Chlorophyll und Assimilation," brings to us a series of papers generally conceded as among the most stimulating contributions to physiology. Here he demonstrates that starch is the first distinctly recognizable product in photosynthesis, and related its formation to the action of light on chlorophyll. Further, he enters into a quantitative study of the product, gravimetrically and with the still much-used iodine test. With the use of tin-foil partially covering the illuminated leaf, he shows the dependence of the product on light, and that it is strictly localized; he shows its decrease under less intensive insolation, its disappearance in the dark, and surmises that it is converted into sugar for translocation.

The fourth section, "Ueber Bewegungen des Wassers in Pflanzen," considers among other things, the experimental evidence on which he based his imbibitional theory. Unfortunately the theory itself has been found wanting, though it must be admitted that many of the details that Sachs gave to us are used in the newer and more satisfactory theories of to-day. To our knowledge of transpiration he added a great deal, and started lines of investigation which are at present still receiving well-deserved attention. His experiments on the saturation capacities of soils of different chemical and physical composition, and the amount of water that a

root system is capable of absorbing, were fundamental in their conception and still offer problems in modern physiology. He successfully correlated transpiration with soil moisture, temperature, acid and alkaline reaction, etc., and insisted that it must be considered with other vital processes of the plant. He recognized the difference between cuticular and stomatal transpiration, and attributed the much greater quantity of the latter to the intercellular spaces in the mesophyll with which the stomates communicate. He supplemented the views of Schwendener and suggested that the turgor phenomena are traceable to the osmotically active substances produced by the chloroplastids in the guard cells, and made the stomates the path of gaseous interchange. He held untenable the view that root-pressure is a factor in the movement of water, but attributed to the suction force of transpiration very much the same office as do the accepted theories of to-day.

In the fifth section, "Ueber das Verhalten der Baustoffe bei dem Wachsthum der Pflanzenorgane," he follows the transformation of the oil in oily seeds into starch and stated that in all probability it was translocated as a sugar. In a series of beautiful figures and comprehensive tables he indicates the presence or absence of oil, starch, or albumin, and thus strengthens his physiologic interpretation of the tissue systems. Following this are four contributions on the germination of the bean, grasses, date, and onion, all worked out with the same care and laying the foundation for all subsequent studies. The last paper in the series concerns itself with the "acid, alkaline, or neutral reaction of living cell saps,"—a title that sounds extremely modern.

The sixth section, "Ueber das Wachsthum von Sprossen und Wurzeln," brings to us his epoch-making studies on growth in which temperature and light are considered in their influence on daily periodicity in growth. Here, too, are given us the observations that brought to our attention for the first time that distribution in the growth phase that he named the Grand Period of Growth; here he gave to us the auxanometer; described and defined nutation in contrast to circumnutation; showed the effect of the environment—air, water, or soil—on the growth of main and lateral roots and of the angle of the latter to the main root, and the distribution of growth in the responsive processes to

gravity, etc. Through his simple demonstration of the growth of a root into mercury, he silenced the contention generally held that the curvature is a mechanical process due to the action of gravity on the root mass, and added another convincing point to his contention that all responses are vital.

In the seventh section, "Ueber die Tropismen als Reiz wirkungen," we find him developing his vital theory to irritability. Here we have the first and most conclusive evidence ever offered of the effect of age or physiologic phase, and of the effects of previous exposure, on the reaction of the plant organ. He calls to our attention the difference in response to the same stimulus of the main and the lateral roots, and introduces the terms orthotropism and plagiotropism. He demonstrates the response of the root to differences in moisture, hydrotropism, and gives us his simple but effective sieve method. In the response of plant organs to light, he lays stress on the importance of the direction of the rays, invents and illustrates the use of the klinostat in investigations of this sort. He calls attention to the difference between growth response and turgor response as illustrated in pulvini.

I feel that I must not close this paper without some reference to the cordial interest that Sachs at all times maintained toward the young men in his laboratory, and his deep conviction that the teaching process is one worthy of serious attention and concern. The following story told me by Professor Fritz Noll only a year after Sachs' death, I am sure, will be of interest to all: Noll had been appointed assistant to Sachs and was entering with fear and trepidation the lecture room for his first lecture. He was met by Sachs who told him that he would find the door leading from his study into the lecture room slightly ajar. This, he said, was not with an eaves-dropping intent, but rather for the purpose of following his lecture while at work, thus to be able to give suggestions for possible improvement. He further requested that Noll call at his (Sachs') office immediately following the lecture. I am sure that all of you can imagine the strain on a young assistant when the master listens intently to the efforts of the amateur. Noll told me that the training there received was of the very best. Always kind and considerate, Sachs would commend Noll on the

manner of presentation of one phase of the subject, but would show him, with kindly consideration to his feelings, how the presentation of another phase could have been much improved.

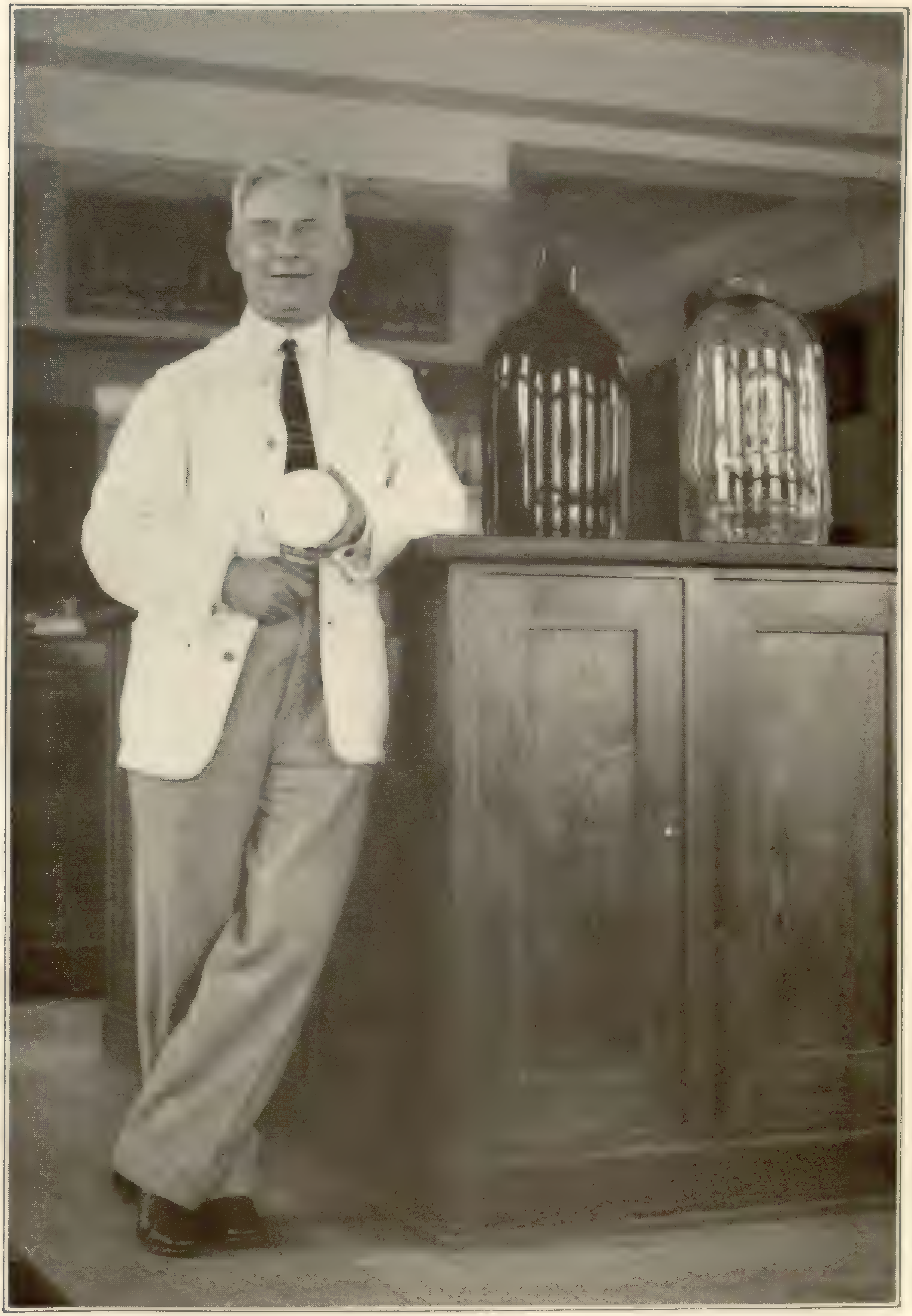
Thus I have briefly reviewed the more important contributions to botany in general, and plant physiology in particular, made by Sachs, the one-hundredth anniversary of whose birth we are here met to celebrate. The number would be greatly increased had I included the many and noteworthy contributions made in his laboratory by such students as Goebel, De Vries, Pfeffer, Vines, Bower, etc. Truly, I think, can the criterion which he used in measuring worthiness for consideration in his History of Botany, be applied to him,—"I have, therefore, singled out those men as the true heroes of our story who not only established new facts, but gave birth to fruitful thoughts and made a speculative use of empirical material."

Explanation of Plate

PLATE 2

Two of three original Bell jars for light experiments made for and used by Sachs at Bonn. Prof. Max Koernicke holding a round marble plate, original root-etching experiment.

Photo by Prof. F. E. Lloyd.



HOTTES—SACHS'S CONTRIBUTIONS TO BOTANY

A HALF CENTURY OF PLANT PHYSIOLOGY[1]

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As has been clearly shown by the preceding essays important work had been done in the mechanics of plant life two centuries before the time of Sachs. He was therefore not the founder of the subject. His activities, however, have exerted a more profound influence on the study of life in plants than those of any worker in the subject and started physiology on a wholly unpredictable development.

The character of laboratory texts, lectures, instruction and research in the dynamics of plant life for the last half century was determined by the experimental investigations and theoretical conceptions developed by Sachs and the group of able workers who participated in the activities of his laboratories. When it is recalled that the list included Baranetzky, Bower, Brefeld, Francis Darwin, Detlefsen, Elfving, W. Gardiner, Godlewski, Goebel, Hansen, Hauptfleisch, Gregor Kraus, Klebs, J. Loeb, Millardet, H. Müller-Thurgau, Moll, Noll, Pedersen, Pfeffer, Prantl, Reinke, D. H. Scott, Stahl, Vines, deVries, Marshall-Ward, Weber, Wortmann, and Zimmermann, nothing more need be said as to his dominating influence on the development of the subject.

Naturally these men, as leading figures in the last decades of the century and the beginning of this, continued work begun with his advice and direction. The literature of the eighties and nineties shows that repetitious tests of the earlier results with extensions and refinements in experimental procedure absorbed a large share of the energies of workers in the laboratories of Central Europe, Great Britain, and America during this period. Work on sensitive tendrils, tropisms, and curvatures, and etiolation, may be cited as illustrations.

Sprouting, germination, and growth in its widest sense came in for great attention, especially since these activities were

[1] A paper read at the celebration held at the Missouri Botanical Garden, December 27, 1931, in honor of the one-hundredth anniversary of the birth of Julius Sachs.

made the criteria of so many tests of nutritive or environic factors. The conception evolved by Sachs of a specific formative material necessary to growth ran its course of usefulness until supplanted by modern studies of accessory substances and regeneration. That many of the findings of Sachs were modified or reversed by the results of more detailed experiments and with improved apparatus and advanced knowledge in no wise detracts from the enduring value of his achievements.

The most valuable feature of the Sachsian contributions was that they set up no falsely appearing dead ends. Down a hundred corridors one might sense doors opening to new vistas. Immediately after Sachs the mechanics of cell-action and the visible features of structure and architecture of protoplasm were followed to the limit of microscopic vision. It soon became evident that the nature of protoplasm was not to be apprehended on the basis of spongy, emulsoid, or foamy structures revealed by the direct-vision microscope. Nearer approach to the essential and characteristic features of living matter was to be made only by studies in the realm of the ultra-microscopic, in which the theoretical conceptions of the colloidal physicist were relied upon to furnish a picture of the molecular meshwork.

The realization of the polyphasic nature of protoplasm has prepared us for the acceptance of the conclusion that the ultra-microscopic and filter-passing viruses are in fact ultimate centers of transformations of energy ordinarily attributed to living things.

Protoplasm was earlier supposed to consist of a mixture of proteins, but biochemical researches have made clear the presence of lipoids in the plasmatic mass and their importance as a colloidal component as well as the part they may play in energy-transformations.

Microdissection has now begun to play an important part in the study of essential characters of chromosomes and other bodies as well as of the plasmatic mass. The earlier conception of the cell-wall as a stratified cellulose formation has been gradually modified until at the present time it is realized that its constitution is determined by the protoplast with which it is intimately and actively connected, so that the expression non-living wall may not be correctly applied to any cell with surviving plasmatic material.

If it became necessary, however, to designate the single conception which has played the greatest part in the development of physiology in the last half century, the choice would undoubtedly be that of electrolytic dissociation and its concomitants. While the actual origin of this conception cannot be given, its formulation in a manner making it available to the physiologist was by Arrhenius in the eighties. With Pfeffer's results in osmosis and DeVries' determinations of isotonic coefficients it constitutes the basis of modern plant dynamics.

The ion or charged particle is now the unit to be considered whether mobilities, interferences, and antagonisms of elements are to be studied in turgidity, permeability, and in nutrition, or whether the electro-kinetic potential of the molecular meshwork of protoplasm is being considered in the connection with hydration and growth.

This paper would be extended far beyond its desirable limits in any attempt to describe the modifications of ideas of plant nutrition in experimentation and in agriculture which have resulted from studies in this field.

Perhaps the earliest effectual co-operation of chemists in the physiological field was that which came in the study of the enzymes. Some of these substances were known in the time of Sachs. Later contributions have consisted in finding a large number of these organic catalysts and in delimiting their specific action, as well as the range of their activity with respect to concentration of the medium, the accumulation of their products, and their relations to temperature. The proteinaceous character of the enzymes has led some writers to consider them as living matter. Some enzymes are known to carry a mineral element in their molecular mesh-work. It is to be recalled here that in addition to these complex bodies simpler catalysts such as some of the mineral elements have become known.

The study of the effects of radiant energy has been extended to observations of great delicacy in phototropism. It is a singular fact that when the philosophic definition of consciousness that makes this state depend upon modification of one irrito-motile reaction by another is applied to plants we do have activities that are, academically speaking, conscious. I refer particularly

to the case where an upright flower stalk in its development reaches a stage where it changes its position from the erect to the horizontal in response to gravity: it does so by a curvature in a direction determined by the impinging light.

Outside of this the basic unity of living matter yields no support for Aristotle's notion of an ascending complexity of living matter from the simplest plants to man. Plants and animals represent the two main surviving streams of living things in which only the inseparable colloidal characters of their living matter are the basis of comparison.

The fact that the organisms are so widely apart in their forms and modes of living calls for dissimilar perceptive mechanisms and transmission of stimuli. The wholly mystic nervous mechanisms and pulsations of Bose have so far eluded all observation, and nothing in the implied conceptions may be properly included within the domain of science, or of reality, or may be deemed worthy of metaphysical consideration.

It is of interest to recall that Sachs, commenting on the futility of the type of explanation in question, said: "We have no necessity to refer to the physiology of nerves in order to obtain greater clearness as to the phenomena of irritability in plants; it will perhaps, on the contrary, eventually result that we shall obtain from the process of irritability in plants data for the explanation of the physiology of nerves, and this, although it is yet a distant hope, gives a special attraction to the study of the irritable phenomena of plants."

Progress in the elucidation of the physical processes of transmission of nervous impulses in animals has, however, gone much farther than our understanding of homologous phenomena in plants. There is much sound evidence of effects being carried some distance by discrete particles or hormones, while in other cases the view that impulses may consist in disturbances of the electro-kinetic balance is favored. The study of the effects of interrupted action of stimulatory, regulatory, excitatory agents on "sensitive" organs has yielded some results which take on added value when compared with reactions in animals.

The study of the effects of duration, intensity, as well as wavelength, in photosynthesis is yielding some valuable results, while

the direct action of radiation in the region of the ultra violet and beyond on living matter is now known to be a matter of great importance in heredity as well as in growth and development.

The most prominent of the basic conceptions of plant physiology which have become the foundation of separate branches of science was that embodied in de Vries' mutation theory of evolutionary procedure. That differentiations in a line of descent should be by measurable units is a theoretical conception essentially physiological, matured in the mind of de Vries who had already contributed studies of electrolytic dissociation and its physiological implications.

It may be recalled that the evolutionary point of view received its earlier support from experimental evidence obtained by Charles Darwin in supplementation of his voluminous observations.

Following his pronouncements a vast literature of polemical writing appeared in which biologists and philosophers endeavored to express to the world what they thought of natural selection and of all other opinions on the subject.

The futility of mere discussion became apparent when de Vries, the experimental physiologist, entered the field presenting some new conceptions based on well-guarded cultures.

Phylogeny, evolution, and heredity were so vivified that researches were started in a hundred laboratories, and a dozen new journals are necessary for the publication of results.

It may be said that Weissmann's conception of germ plasm as the carrier of hereditary traits, invincible, inviolate and unmodifiable by environic causes, still holds, but only as conventional expression of the inertia of a strain of descent. Recent results, especially those obtained by subjecting organisms to the action of radiant energy of unaccustomed intensity or wave frequency, may destroy genes and alter linkages of characters causing breaks in transmission of hereditary characters of the most serious kind.

Practically all of the development of the study of bacterial organisms has been of a physiological character. The pathological action of these organisms on animals and man and crop plants has resulted in a development of this work into a separate branch with its own literature and laboratories, especially in pathology, in which fungi are also dealt with.

The separation has not gone so far, however, as to free the physiologist from his burden of understanding the action of soil bacteria and of fungi co-operating with the roots of higher plants in mycorrhizal arrangements.

Physiology has gone afield and quite literally in another manner in ecology. The study of organisms in a state of nature has been taken up by methods wholly new or materially modified from those which have been perfected in the laboratory. Physiology has thus been extended from the sea and the lakes, through swamps, fields, orchards, woods, plains and deserts to the mountain tops, with a development of many generalizations of the first rank.

Researches on the water-relations of plants have been widely extended in measuring transpiration, in the evaluation of the internal conditions and external agencies affecting the rate and amount. Attention directed to soil moisture and its use by the plant has resulted in a maze of literature of enormous volume. The wealth of facts recorded concerns almost all cultures, experimental or practical. The rate of loss, as well as the degree of hydration of the protoplasmic meshwork, affects almost all phases of metabolism and transformations of energy in the plant.

It is on the basis of these relations that water-loss is now taken to have been a prime factor in the evolutionary development of the higher plants, the ultimate expression of which is to be seen in the spinose and succulent forms of deserts.

The matter of the upward movement of sap has the distinction of a literature in which the essential problems were recognized two hundred and fifty years ago in the communications of Nehemiah Grew and of Malpighi to the Royal Society of London (1681). A little over two centuries ago (1727) Stephen Hales contributed notably to the subject, following which no contribution of enduring value was made until after the time of Sachs, although he and his co-workers and followers brought out a multitude of facts and a variety of explanations. The next notable advance was reported to the Royal Society in London by Dixon and Joly in 1895, this being the beginning of the development of the cohesion theory of the hydrostatic system of higher plants. The meshwork of water extending continuously from the

soil solutions wetting the root-hairs through the walls and lumina of vessels, tracheids, the colloidal masses of living cells in leaves terminating in ultra-microscopic meniscuses in the walls exposed to ventilated air spaces in the leaves, is the physical basis of this mechanism. The tensions set up by deformations in these surfaces may be as great as 200 atmospheres, and this pull is exerted on a meshwork of watery filaments capable of sustaining a stress of 300 pounds to the square inch. The configuration of this network or the path of sap varies widely with the morphology of the stems.

It is only since the time of Sachs that the transport of material from leaves or photosynthetic organs through petioles and stems to developing organs has been taken up seriously. No definite agreements have been reached as to the conduits, or the forces which are engaged. No comprehensive proposals have yet been made which can be taken as adequate to account for the amount and velocity of movement of the sugars, generally downward in the stem, although this subject has received the serious attention of some very able experimenters.

The amount and rate of upward flow of sap require the units of energy noted above, but it is also to be noted that the electrokinetic potential shows a gradient oriented to promote the flow in the xylem toward the apex of stems. Whether a reverse gradient found in the cortical region might be of importance in the movement of carbohydrates toward the base of the plant is a matter yet to be determined. The origin and nature of the so-called "root-pressure" is also undetermined after more than two centuries of observations and experiments.

The increases which are considered as growth in the broadest sense, the study of which received so much attention in Sachs' laboratory, have been for the most part dealt with by external measurements of one or two dimensions of organs, by total weight of individuals, by dry weight, or by counts of unicellular organisms. The approach is organogenic in any case. Studies of this character are essentially biographical, following the development of an individual or an organ from egg, parent cell or initial part way or on to maturity.

Earlier, the results were expressed in graphs showing the course

of growth plotted as velocities. During the last twenty-five years various efforts have been made to put the results into mathematical formulae. The rate of increase has been expressed in terms of the initial dry weight, and as compound interest on the initial dry weight.

Another view is that growth of an organ or individual may be given in the formula of an auto-catalytic reaction in which substance continuously secreted by the plant is the catalyst. The possibility of the identification of such a theoretical catalyst with the substance promoting fluidity or extensibility of the cell-walls is now meeting with some approval.

The analytical approach to the matter of growth is essentially that of Sachs who considered that division, elongation and differentiation are the stages from generative cells to permanent tissue. These three steps may now be characterized more closely as to the physical action involved.

During the first part of the existence of a new protoplast the dominant action is one of condensation of proteins and lipoids in a field near the iso-electric point nearly neutral or even slightly alkaline. The difference in this feature of the nucleus and of the cytoplasm is very slight. The entire protoplast has a low coefficient of hydration and permeability. Numerous very minute vacuoles are present which seem to have no connection with those that cause distention in the following stage.

With the attainment of full size, and seemingly consequent upon the movement of the chondriosomes from the neighborhood of the nucleus toward the periphery of the mass, a hysteresis or accumulation of solutions in vacuoles takes place. The osmotic action of these solut ons which may have a value of 75 or 80 atmospheres is now the distentive agency which may enlarge the cell to as much as a thousand times its initial volume at a rate presumably regulated by the special catalyst present. The amount of protoplasm remains but little changed; dry weight of walls and other solids increase greatly.

Some proteins are broken up and some mucilages are formed. Granular bodies appear in the cytoplasm and the cellulose wall is formed. The H ion concentration increases in both nucleus and cytoplasm, but most in the external layers so that in a dis-

tended parenchymatous cell the nucleus may show pH 5.5, and the outer part of the cell pH 4 to 4.5.

Whatever validity the equations of growth calculated on dry weight or volume supporting the auto-catalytic nature of growth may have will depend on their correct expression of the formation and action of the accessory substance which increases the extensibility of walls in the distending stage, as the change in volume in the initial stage and in the final differentiation forms a very low proportion of the total increase in volume.

Differentiation may be least in parenchymatous cells, or it may be carried to the extreme limits known to the anatomist, with the progressive consumption or wastage of the protoplast. The final disappearance of living matter from a cell leaves it in a condition where only mechanical uses are served, such as rigidity, or as conduits of solutions or gases.

The theory of Sachs as to specific organ-forming substances has been gradually modified, so that now it is taken for granted that construction is at the expense of general food-material, forming proteins and lipoids at first and carbohydrates later. His idea is now replaced by the conception of regulatory agents facilitating distention by increasing the fluidity or plasticity of cell-walls. There is also good evidence of the action of substances which retard growth by influencing condensation or distention.

Two major modifications of our conception of living matter have been made in the last two decades in addition to those disclosed in the studies of the mechanism of heredity. One is to the effect that protoplasmic units, such as those in meristematic layers, display no inherent rhythms except as enforced by variations in the environment. Thus no periodicities have been discernible in the cultures of cell-masses from embryo chicks by Carrel, which have been carried along for nearly two decades.

Likewise we know that growing points and sheets of cambium show no regularly recurring variations of their own. The variations displayed are all resultant from seasonal changes, maturation of permanent tissues, the depletion or repletion of the available food-supply, loss or cessation of function of such organs as leaves. In other words, periodicity in plants complies with the seasons or is organogenic, but not protoplasmic.

Our generalizations as to the inertia of protoplasm have also been modified by observations as to the durability of the delicately balanced mechanism of living material. It is now known that protoplasts may live for centuries. This is quite aside from scholastic discussions as to the immortality of primitive organisms in which death of the individual is replaced by its division into two others which, with their descendants, undergo scission instead of death.

In our own laboratories we have identified not only parenchymatous cells, but also other elements, such as wood-fibers, well on their way toward mature differentiation, in which the protoplasmic bodies retain an effective organization through several centuries. In some of the solid bodies there is fair certainty that the actual molecular meshwork has continuously existed without replacement. Buried seeds have shown similar longevity, and it is highly probable that these structures could be prepared to survive tens of centuries with their low rate of metabolism.

Progress in the study of the energetics of the green plant as pertaining to chlorophyll action and to the energy-releasing reactions under respiration may not adequately be described in a brief discussion. Since the discovery of respiration by green plants by Ingenhousz in 1774, and Rollo's detection of the excretion of carbon dioxide by plants in the absence of free oxygen, in what later was termed intra-molecular respiration, research has been directed to the identification of the substances which were subject to oxidation, and of the products. The first attempt at standardization in this field was in the determination of the oxygen-carbon dioxide quantitative relation or respiratory quotient. This has been found to be affected by a wide variety of agencies. The excretion of oxygen by green plants in light, discovered by Priestley in 1772, may be taken as the initial observation of photosynthesis, but the subject was not given its modern form until the time of Sachs. It seems to be agreed that Sachs is to be credited with the realization of the action of the chloroplasts, and that chlorophyll was formed only in the presence of light.

The last half century of research has included many attempts to identify the primary processes and products in respiration, and

photosynthesis. In neither field have there been achieved decisive results, although a great volume of information has been accumulated which may be expected to fall into place when a comprehensive theory of the implied activities is propounded.

The effort is now being made to determine the unit of radiant energy necessary to produce a certain effect in this process, which might become a general standard of measurement of energy exchange or transformation in the plant.

With the earlier development of methods, physiologists, in striving for precision, fell into the grave error of an extreme concentration on specific effects. Thus, for example, a certain intensity of illumination, a certain temperature, or some concentration of a mineral salt was supposed to have an unvarying effect; and this was sought in the praiseworthy urge for standardization. It has dawned but slowly on the physiologist that the causative action of any one agency is conditioned by the intensities of all other forces acting on the organism. All of these have a range from zero to an endurable maximum, and any one of them may become a "limiting factor" in a process or in an organogenic development.

Physiology attracted researchers of ability in Europe from the time of Sachs. Its recognition as a phase of botanical science in America came two decades later in America. Dr. J. C. Arthur appointed to the chair of plant pathology and physiology at Purdue University, and myself, appointed as assistant professor of botany in charge of plant physiology at the University of Minnesota in 1893, seem to have held the first research and teaching positions, although the subject was being presented in a few botanical departments elsewhere.

That the subject included the processes basic to agriculture dawned but slowly even in the most advanced agricultural colleges. Here it may be in charge of members of the staff holding the most diverse titles. Its contributions appear in a great number of journals of a range far beyond the direct interests of biological science.

The opportunities for research and the facilities for teaching have grown in pace commensurate with those in cognate sciences. Chairs, departments, and laboratories are numerous: some are well equipped.

The requirements of a laboratory which gives instruction and advanced work and offers opportunities for research are much greater than for a department of animal—often termed general—physiology. Instruments of precision, specially designed optical, physical, and chemical apparatus, chambers and glass houses, a stock of growing material and a garden of some sort, are among the indispensables as contrasted with the window-ledge experiments with lamp-chimneys, remodeled alarm clocks, tinware, and kitchen appliances of forty years ago.

Not the least important feature of my subject is that of the change in the relations of the experimental scientist to his fellow man and to society in the period under discussion. At its beginning "pure science" really meant "sterile learning," devoid of human interest. The world at large was not interested in the results gained in technical laboratories, which achieved publicity only when they seemed, to the lay mind, blasphemous, or as trespassing on the "secrets of nature."

The scientist reacted to such a set of environmental conditions with an attitude of disinterest in the practical implications of his findings. Science and life were utterly apart.

The contrast with to-day is worth a moment's consideration. Some of you will present results at New Orleans which will appear in newspapers with a million readers within the week and may perhaps be put on the cables for foreign readers. This ready recognition may come for a new theory on some phase of protoplasmic activity, or for methods of using known facts for the benefit of the race.

Increased appreciation of the importance of our studies calls for a full sense of our responsibilities. The interests of the plant physiologist run back to that early stage of living matter when chlorophyll, or other sun-screens, was first developed. The problems of life he seeks to solve are those which began to crowd the stage of the world consequent upon this direct utilization of the sun's energy: they concern the existence and continuation of the entire organic world.

The technology of any worker who may contribute to knowledge in this great field must be stark, precise, and as free of mysticism as of sentimentalism. He has no magic carpet, but

falls into the chasms encountered unless he succeeds in bridging them or passing on temporary or "false" work.

Vitalism is to him the ready recourse of baffled minds, unequal to the relentless demands of sound experimentation. That there may be forms of energy releases in living matter not yet recognizable, which, like the ultra-Plutonian planets, disturb calculations of the protoplasmic system, is admitted.

To our contemporaries, however, the physiologist has come to be known as a worker deeply immersed in a bewildering maze of phenomena. His entire attention is given to compilation of refined methods and systemization of results, with but little attempt at realization of the broader philosophical aspects of his subjects.

Plant physiology has developed a sound methodology for the study of living matter, its involutions, properties, performances in functions, organogenesis, heredity, and evolutionary development. It has for this half century drawn upon chemistry and physics in perfecting a technique which has been extended with great profit in genetics, bacteriology, and ecology. The utilization of its methods has been of incalculable advantage in agriculture and the plant industries.

Researchers in physiology have been regrettably content with the vast array of material facts secured by experimentation and have not carried their work toward a realization of the first principles or abstract possibilities of living matter and of the broader aspects of the organic world. Research is most worth while when it is a search for explanatory knowledge.

Philosophical considerations which look toward analytical explanations are as truly ours to use as our laboratory equipment. The restricted conclusions based on tests and measurements may have but small importance in comparison with a metaphysical aspect of the possibilities. The constructive value of a contribution is not to be determined by the mass of facts presented, not by the bricks and mortar, steel and concrete it furnishes, but by the architectural conceptions which may be realized by the use of these materials.

NEW OR OTHERWISE NOTEWORTHY APOCYNACEAE OF TROPICAL AMERICA. II[1]

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Allomarkgrafia Woodson, gen. nov. Apocynacearum (Echitoideae). Calyx profunde 5-partitus; laciniae subaequales scariaceae margine imbricatae basi intus multiglandulosae. Corolla speciosa infundibuliformis; tubus inferne anguste cylindricus dein circa medium staminiger et late campanulato-dilatatus numquam constrictus; limbi laciniae 5 aequales oblique obovato-reniformes aestivatione dextrorsum convolutae. Stamina 5 omnino inclusa; antherae inter se adglutinatae et stigmati adplicatae anguste oblongo-sagittatae basi obtuse biauriculatae dimidia parte superiore pollinigerae, sporangiis binis omnino fertilibus, pollinibus granulosis; filamenta subcylindrica brevissima saepissime retrorse pilosa. Ovarii carpella gemina basi distincta apice in stylo gracili producta, ovulis multis pluriseriatim superpositis; stigma fusiforme obscure 5-gonum apice obtusum. Nectarii glandulae 5 separatae vel basi plus minusve connatae. Fructus folliculares apocarpi tereti longe acuminati plus minusve falcati; semina numerosa subscaphoidea in longitudinem unisulcata apice bene comosa.—Frutices lactescentes volubiles; folia opposita petiolata subcoriacea integra penninervia, nervis principalibus basi ventro pluriglandulosis. Inflorescentia lateralis alternata multiflora omnino 2–3-chotome divisa, ramis bostrycino-racemosis divaricatis, pedicellis geminis unibracteatis.

Allomarkgrafia ovalis (Mgf.) Woodson, n. comb.

Echites ovalis Mgf. Notizblatt **9**: 79. 1924.

Echites ovalis Tafalla, ex Mgf. loc. cit. 1924, nom. nud. in synon.

The genus most closely allied to *Allomarkgrafia* is without doubt *Mesechites* Muell.-Arg., a valid group which has been generally ignored and confused with *Echites* P. Br., largely as a result of the efforts of John Miers in the past century. *Allomarkgrafia* has

[1] Issued April 15, 1932.

a large, infundibuliform corolla, whereas all the known species of *Mesechites* have much smaller, salverform corollas. The construction of the inflorescence is also diverse, that of the former genus being regularly branched with relatively distant, opposite pedicels, whereas that of the latter is characterized by irregular branching and extremely congested, indistinctly distributed pedicels. The foliar glands differ, furthermore, since those of the former are numerous and densely and indefinitely clustered, while those of the latter usually number but two or three and are regularly (either concentrically or radially) placed. A final and very important generic criterion is found in the number and disposition of the calycine squamellae, which are extremely numerous and uniformly distributed in *Allomarkgrafia*, and are only ten to fifteen in number and are placed strictly opposite the calyx-lobes in *Mesechites*.

The genus cannot be included within *Echites* P. Br. because of the obtusely auriculate anthers bearing uniformly fertile sporangia, the indeterminate inflorescence, and the foliar glands at the base of the midrib, which characterize it.

Allomarkgrafia has been so named in honor of Dr. Fr. Markgraf of the staff of the Botanical Museum at Berlin-Dahlem.

Asketanthera Woodson, gen. nov. Apocynacearum (Echitoideae). Calyx majusculis profunde 5-partitus; laciniae foliaceae plus minusve inaequales margine imbricatae intus basi squama deltoidea instructae. Corolla parva vel magna circa medium vel inferius 5-partita; tubus cylindricus infra medium staminiger; limbi aestivatione dextrorsum convoluti laciniae oblique ovato-lanceolatae. Stamina 5 inclusa; antherae in conum adglutinatae et stigmati adplicatae anguste ellipsoideo-oblongae basi acute bilobatae dimidia parte superiore pollinigerae, sporangiis binis basi in appendiculas rigidas productis, pollinibus granulosis; filamenta subcylindrica perbrevia saepissime pilosa. Ovarii carpella gemina basi distincta apice in stylo gracili producta, ovulis multis pluriseriatim superpositis; stigma fusiforme 5-gonum apice obscure bipartitum. Nectarii glandulae 5 saepissime separatae vel basi paulo connatae. Fructus folliculares apocarpi anguste tereti acuminati plus minusve falcati; semina numerosa sub-

scaphoidea in longitudinem unisulcata apice truncata vel paulo attenuata comosa.—Frutices lactescentes volubiles; folia opposita petiolata membranacea penninervia eglandulosa. Inflorescentia lateralis vel rarius subterminalis alternata bostrycino-racemosa bracteis foliaceis.

Asketanthera calycosa (A. Rich.) Woodson, n. comb.
Echites calycosa A. Rich. Fl. Cub. Fanerog. **2**: 94. 1853.
Rhodocalyx calycosus (A. Rich.) Miers, Apoc. So. Am. 140. 1878.
Echites Rugeliana Urb. Symb. Ant. **5**: 465. 1908.

Asketanthera dolichopetala (Urb.) Woodson, n. comb.
Echites dolichopetala Urb. Symb. Ant. **7**: 335. 1912.

Asketanthera longiflora (Ekm. & Helwig) Woodson, n. comb.
Echites longiflora Ekm. & Helwig, Ark. f. Bot. **22A**[10]: 45. 1929.

Asketanthera Picardae (Urb.) Woodson, n. comb.
Echites Picardae Urb. Symb. Ant. **5**: 466. 1908.

Asketanthera, a genus confined to the Greater Antilles, constitutes an extremely conspicuous and natural complexity of four species, as at present understood, each apparently endemic to a particular island or island group. *A. calycosa*, which is to be regarded as the type species, is limited to the island of Cuba, where it is of frequent and wide occurrence. *A. longiflora*, a native of Hispaniola, is more rare, and is noteworthy as bearing perhaps the largest and most beautiful flowers to be found among the Apocynaceae.

From *Echites* P. Br., with which it has its closest affinities both morphologically and geographically, *Asketanthera* differs markedly in the construction of the inflorescence, which is a compound, though frequently much reduced, dichasial cyme in the former, and a simple, bostrychoid raceme in the latter; in the character of the bracts and calyx-lobes, which are scarious and inconspicuous in the former genus, and foliaceous and extremely conspicuous in the latter; and in several more technical details of the repro-

ductive apparatus. The superficial dissimilarity of the genera is striking.

The generic name has been coined from ἀσκητός and ἀνθηρά, with reference to the highly modified stamens.

Fernaldia Woodson, gen. nov. Apocynacearum (Echitoideae). Calyx profunde 5-partitus; laciniae aequales vel subaequales margine imbricatae basi intus uniglandulosae. Corolla speciosa infundibuliformis; tubus inferne longe cylindricus supra medium late campanulato-dilatatus numquam constrictus ad basin partis dilatatae staminiger; limbi laciniae oblique obovatae aestivatione dextrorsum convolutae paulo reflexae in paginis ventralibus saepissime dense arachnoideo-villosae. Stamina 5 inclusa; antherae inter se adglutinatae et stigmati adhaerentes sagittatae anguste oblongo-ellipsoideae basi inconspicue obtuseque bilobatae parte dimidia superiore pollinigerae, sporangiis binis basi in appendiculas rigidas conspicue productis, pollinibus granulosis; filamenta brevia cylindrica glabriuscula. Ovarii carpella gemina basi distincta apice in stylo gracili producta, ovulis multis anatropis in utraque loculo pluriseriatim superpositis; stigma fusiforme obscure 5-gonum apice vix bipartitum. Nectarium cupuliforme inaequaliter 4-lobatum. Fructus folliculares apocarpi anguste cylindrici longe acuminati plus minusve falcati; semina numerosa subscaphoidea longitudinaliter unisulcata apice truncata bene comosa.—Frutices lactescentes volubiles; folia opposita petiolata margine integra penninervia eglandulosa. Inflorescentia lateralis rariusve subterminalis multiflora valde racemosa.

Fernaldia pandurata (A. DC.) Woodson, n. comb.

Echites pandurata A. DC. in DC. Prodr. **8**: 458. 1844.

Amblyanthera ? pandurata (A. DC.) Muell.-Arg. Linnaea **30**: 448. 1860.

Angadenia pandurata (A. DC.) Miers, Apoc. So. Am. 182. 1878.

Mandevilla velutina K. Sch. in Engl. & Prantl, Nat. Pflanzenfam. 4^2: 171. 1895.

Mandevilla potosina T. S. Brandg. Univ. Calif. Publ. Bot. **4**: 276. 1912.

Echites pinguifolia Standl. Field Mus. Publ. Bot. **8**: 35. 1930.

Although the infundibuliform corolla, racemose inflorescence, and bluntly auriculate anthers would appear superficially to ally *Fernaldia* to *Mandevilla* Lindl., it is actually more nearly related to *Echites* P. Br. This affinity is indicated by the eglandular foliage, the fusiform stigma, and the sporangia of the anthers, which are produced into a conspicuous, inwardly protuberant, sterile base.

From *Echites*, *Fernaldia* differs in the structure of the inflorescence, which is cymose in the former and racemose in the latter; in the shape of the corolla, which is salverform in the former and infundibuliform in the latter; in the anthers, which are produced into two sharp, basal prongs in the former, and are merely obtusely bilobed in the latter; and in the nectary, which is composed of five essentially equal and separate glands in the former genus, and is a cylindrical, irregularly four-lobed structure in the latter. *Fernaldia* differs from *Urechites* Muell.-Arg., furthermore, since it is without the terminally appendiculate anthers, the chaffy placentae, and the rostrate seeds which distinguish the latter genus. The arachnoid-villous corolla-lobes are without a parallel among the American Echitoideae.

The genus has been named in honor of Prof. Merritt Lyndon Fernald of the Gray Herbarium of Harvard University, who questioned the current generic interpretation of the type species while engaged in a study of the collections of Dr. Edward Palmer in southern Mexico.

Galactophora Woodson, gen. nov. Apocynacearum (Echitoideae). Calyx majusculis profunde 5-partitus; laciniae aequales vel subaequales margine imbricatae intus basi esquamuligerae sed saepissime glandulas minutas extra-axillares sparse munitae. Corolla magna speciosa; tubus inferne breviter cylindricus circa medium vel inferius late campanulato-dilatatus numquam constrictus ad basin partis dilatatae staminiger; limbi laciniae 5 aequales oblique obovatae aestivatione dextrorsum convolutae paulo reflexae. Stamina 5 omnino inclusa; antherae inter se plus minusve adglutinatae et stigmati adplicatae oblongo-lanceolatae sagittatae basi acute bilobatae parte dimidia superiore pollinigerae, sporangiis binis basi in appendiculas rigidas conspicue productis, pollini-

bus granulosis; filamenta subcylindrica brevissima pilosa. Ovarii carpella gemina basi distincta apice in stylo capillaceo longe producta, ovulis in utraque loculo pluriseriatim superpositis; stigma fusiforme obscure 5-gonum apice bipartitum. Nectarium cupuliforme apice obscure 5-lobatum. Fructus folliculares apocarpi anguste cylindrici longe acuminati plus minusve falcati; semina numerosa subscaphoidea in longitudinem unisulcata apice truncata ibique bene comosa.—Suffrutices erecti; folia opposita petiolata vel subsessilia saepe amplexicaulia coriacea penninervia eglandulosa. Inflorescentia terminalis bostrycino-racemosa pauciflora.

Galactophora crassifolia (Muell.-Arg.) Woodson, n. comb.

Amblyanthera crassifolia Muell.-Arg. in Martius, Fl. Bras. **6**[1]: 143. 1860.

Echites crassifolia Spruce, ex Muell.-Arg. loc. cit. 1860, nom. nud. in synon.

Rhodocalyx crassifolius (Muell.-Arg.) Miers, Apoc. So. Am. 139. 1878.

"*Mandevilla crassifolia* Muell.-Arg." ex K. Sch. in Engl. & Prantl, Nat. Pflanzenfam. **4**[2]: 171. 1895, sphalm.

"*Mandevilla crassifolia* (Spruce) K. Schum." ex Mgf. in Fedde, Rep. **20**: 24. 1924, sphalm.

Galactophora calycina (Hub.) Woodson, n. comb.

Dipladenia calycina Hub. ex Ducke, Archiv. Jard. Bot. Rio Janeiro **3**: 247. 1922; Bol. Mus. Goeldi **7**: 113. 1913, nom. nud.

Galactophora Schomburgkiana Woodson, sp. nov., suffrutescens; caulibus erectis teretibus sat crassis altitudine ignotis junioribus tenue glandulo-puberulis tandem glabratis; foliis oppositis subsessilibus paulo amplexicaulibus coriaceis margine in sicco revolutis late ovatis apice obtusiusculis basi subiter rotundatis et obscure cordatis 4–7 cm. longis 2.5–4.5 cm. latis supra tenuissime puberulis mox glabratis subtus glabris vel junioribus tenuissime puberulis; petiolis 0.1–0.2 cm. longis; inflorescentiis umbellatis paucifloris; pedunculis 3–5 cm. longis ut in caulis vestitis; pedicellis 1.0–1.5 cm. longis glandulo-puberulis et parce aculeolatis;

bracteis squamosis minimis; calycis laciniis ovatis acutiusculis 0.5–0.6 cm. longis scariaceis minutissime puberulis haud aculeolatis; corollae infundibuliformis extus minutissime glanduligerae in longitudinem aculeolato-striatae tubo 5–6 cm. longo basi ca. 0.2 cm. diametro metiente usque ½ altitudinem anguste cylindrico dein staminigero et campanulato-dilatato ostio ca. 0.75 cm. diametro metiente lobis oblique obovatis ca. 1 cm. longis; genitalibus ignotis; folliculis teretibus sat crassis ca. 14 cm. longis extus dense glandulo-aculeolatis.—BRITISH GUIANA: exact locality and date lacking. *R. Schomburgk s. n.* (Herbarium Kew., TYPE, Mo. Bot. Garden Herbarium, photograph).

Closely allied to *G. crassifolia* and *G. calycina*, but differing from both in the smaller calyx-lobes, which are but 0.5–0.6 cm. long and contrast sharply with those of the two related species which are 1.5–2.0 cm. long. The foliage, moreover, is ovate, whereas that of the allied species is broadly oblong. Because of the peculiar aculeolate emergences of the corolla, *G. Schomburgkiana* is considered to be more nearly related to *G. crassifolia.*

Galactophora pulchella Woodson, sp. nov., suffrutescens; caulibus erectis teretibus tenuibus altitudine ignotis junioribus minute puberulis tandem glabratis et lenticellas parvas gerentibus; foliis oppositis petiolatis subcoriaceis ovato-oblongis apice obtusiusculis basi subiter rotundatis vix cordatis 3.5–6.0 cm. longis 2.5–4.0 cm. latis supra glabratis subtus minutissime sparseque puberulis; petiolis 0.3–0.5 cm. longis glabris; inflorescentiis bostrycino-racemosis 5–10-floris; pedunculis 3–5 cm. longis ut in caulis vestitis; pedicellis ca. 0.75 cm. longis glabris vel minutissime glandulo-puberulis; bracteis scariaceis lanceolatis 0.15–0.2 cm. longis; calycis laciniis anguste lanceolatis 0.5–0.75 cm. longis scariaceis minute glandulo-puberulis et parce aculeolatis; corollae infundibuliformis glabrae vel paulo papillatae vix aculeolatae tubo 6–8 cm. longo basi ca. 0.2 cm. diametro metiente usque ¾ altitudinem anguste cylindrico dein staminigero et paulo ampliore tubuloso-dilatato ostio ca. 0.4 cm. diametro metiente lobis oblique ovato-oblongis obtusiusculis 1.0–1.25 cm. longis paulo reflexis; antheris anguste lanceolatis 0.5–0.6 cm. longis basi acutissime auriculatis dorso minute puberulo-papillatis; nectario cupuliformi apice 5-lobato ovariis oblongoideis glabris paulo breviore; folliculis igno-

tis.—Brazil: Cano Pimicheiro, June, 1854. *R. Spruce 3718* (Herbarium Kew., type, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

Distinctive because of its narrowly tubular corolla-throat and lanceolate calyx-lobes. It is also the only species of the genus with foliage which is not amplexicaul.

The type specimens of the two species immediately preceding were found in the collection of undetermined Apocynaceae at the Herbarium of the Royal Botanic Gardens, Kew. Both are evidently unicates, as duplicates have been encountered in none of the other European or American herbaria which have been consulted during the course of these studies.

Galactophora is a genus apparently without any direct affinity among the genera of its subfamily. Because of its esquamuligerous calyx and infundibuliform corolla, it is thought that *Rhabdadenia* may be considered as closely allied. The two genera, however, are of entirely different habit, *Rhabdadenia* consisting of extensive lianas for the most part, and *Galactophora* of low, suffrutescent undershrubs. The nectaries of the former genus are essentially separate, moreover, whereas those of the latter are completely concrescent. Furthermore, the seminal coma of *Rhabdadenia* is borne upon a slender rostrum, while that of *Galactophora* is sessile. The glandular-aculeolate emergences of the corolla, calyx, and stems of the latter genus are unique in the entire family as at present understood. The provenience of the Latin designation is obvious.

Mandevilla tubiflora (Mart. & Gal.) Woodson, n. comb.

Echites tubiflora Mart. & Gal. Bull. Acad. Roy. Brux. **11**: 358. 1844.

Amblyanthera tubiflora (Mart. & Gal.) Muell.-Arg. Linnaea **30**: 423. 1860.

Echites Cobanensis Donn.-Sm. Bot. Gaz. **40**: 6. 1905.

What is evidently the sole surviving specimen of Galeotti's original collection (no. *1579*) has recently been discovered among the undetermined Apocynaceae in the herbarium of the Royal Botanic Gardens, Kew, and discloses the corolla of this species to be typically salverform, with a conspicuous, spreading limb.

Another species, collected upon several occasions by C. G. Pringle and Dr. Edward Palmer in southern Mexico and widely distributed as *Echites tubiflora* Mart. & Gal., is characterized by an almost precisely tubular corolla, with an inconspicuous, erect limb, and appears to constitute a novelty:

Mandevilla Syrinx Woodson, sp. nov., suffruticosa volubilis; ramulis gracilibus juventate puberulis tandem glabratis; foliis oppositis breviter petiolatis membranaceis elliptico-ovatis vel oblongo-lanceolatis plerisque profundiuscule cordatis apice imo in acumen breve constrictis supra hispidulis glabratisve nervo medio basi pluriglandulosis subtus pallidioribus tomentulosis vel rarius laxe pilosis 5–14 cm. longis 1.5–8.0 cm. latis; petiolis 0.5–1.0 cm. longis puberulis; inflorescentiis racemosis lateralibus vel subterminalibus alternatis multifloris; pedunculo foliis subaequante ut in ramulis vestito; pedicellis congestis subsecundis 0.3–0.5 cm. longis; bracteis ovato-lanceolatis linearibusve scariaceis pedicellis subaequantibus; calycis laciniis ovatis vel ovato-lanceolatis acuminatis 0.3–0.5 cm. longis scariaceis extus minute puberulo-papillatis intus basi squamellas multas flagelliformes uniforme munitis; corollae tubiformis dilute flavidulae tubo cylindrico 0.5–0.75 cm. longo basi ca. 0.2 cm. diametro metiente circa medium vel inferius staminigero faucibus paulo ampliatis lobis late ovatis acutiusculis erectis ca. 0.4 cm. longis; antheris anguste oblongo-lanceolatis basi truncate auriculatis 0.4 cm. longis; ovariis late ovoideis dense puberulo-papillatis apice in stylo abrupte contractis 0.2 cm. longis; stigmate proprio 0.2 cm. longo apiculis paulo breviore; nectarii glandulis oblongoideis plus minusve distinctis ovariis aequantibus vel paulo superantibus; folliculis falcatis glabris haud articulatis 15–25 cm. longis; seminibus ca. 0.1 cm. longis como dilute flavido dimidio brevioribus.—MEXICO: Jalisco: barranca of Tequila, Oct. 8, 1893. *C. G. Pringle 5422* (Mo. Bot. Garden Herbarium, TYPE).

A number of collections of this species has already been made in the Mexican states of Jalisco, Michoacan, Morelos, Guanajuato, and Oaxaca, representing a considerable degree of variation in such characters as the foliar indument and the length and degree of attenuation of the calyx-lobes. Without field observation,

or, at any rate, still more ample specimens, however, it has been decided to forego the creation of a number of intergrading varieties.

The curiously erect limb of the corolla, combined with the strikingly compact, subsecund inflorescence, has suggested as a substantive adjective for the species the name of the familiar wind instrument of the classical Greeks.

Mandevilla acutiloba (A. DC.) Woodson, n. comb.
Echites acutiloba A. DC. in DC. Prodr. **8**: 451. 1844.
Amblyanthera acutiloba (A. DC.) Muell.-Arg. Linnaea **30**: 426. 1860.

The original specimen of *M. acutiloba* collected by Pavon and now incorporated within the Herbier Boissier at Geneva is without data concerning locality. A specimen in the United States National Herbarium, collected in the state of Chiapas, Mexico, near Tumbala, by E. W. Nelson (no. *3337*), however, coincides well with that of Pavon, and might be assumed to have come from approximately the same general region. In any event, it appears evident that the latter is either Mexican or Central American in origin, since it possesses the hypogynous nectaries equalling or slightly surpassing the ovary, the long-apiculate stigma, and the blunt anther-lobes characteristic of the salverform-flowered Mexican and Central American species of the subgenus *Eumandevilla*. All known South American species of *Eumandevilla* bearing salverform corollas have nectaries surpassed by the ovary, shortly apiculate stigmata, and anthers which are without basal lobes. It is extremely unfortunate that the species is as yet represented by but two specimens among the principal herbaria of both Europe and America.

Mandevilla Donnell-Smithii Woodson, sp. nov., suffruticosa volubilis; ramulis teretibus gracilibus dense puberulis; foliis oppositis petiolatis membranaceis late ovatis vel ovato-oblongis profunde cordatis apice breviter acuminatis 4–10 cm. longis 2–8 cm. latis supra viridibus dense hirtellis nervo medio basi pluriglandulosis subtus pallidioribus tomentosis; petiolis 0.75–3.0 cm. longis tomentulosis; inflorescentiis racemosis lateralibus alternatis

10–25-floris; pedunculo foliis aequante vel paulo superante ut in ramulis vestito; pedicellis secundis plus minusve congestis 0.5–0.75 cm. longis; bracteis scariaceis anguste lanceolatis 0.2–0.5 cm. longis; calycis laciniis scariaceis ovatis vel oblongo-lanceolatis acuminatis 0.2–0.4 cm. longis extus obscure puberulis intus basi pluriglandulosis; corollae salverformis dilute flavidae tubo cylindrico 1.25–1.5 cm. longo basi ca. 0.15 cm. diametro metiente supra medium staminigero faucibus paulo ampliatis lobis oblique obovatis obtusiusculis patentibus 0.25–0.4 cm. longis; antheris ovatis vel late oblongis basi truncate auriculatis 0.4 cm. longis; ovariis ovoideis apice subiter constrictis ca. 0.15 cm. longis glabris; stigmate proprio ca. 0.1 cm. longo apiculis sterilibus subaequante; nectarii glandulis oblongo-ovoideis plus minusve distinctis ovariis aequantibus vel eadem paulo superantibus; folliculis ignotis.—GUATEMALA: Dept. Santa Rosa: Cerro Gordo, alt. 3500 pp., Aug., 1892. *H. T. Heyde & E. Lux 3993* (Gray Herbarium, TYPE, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

Superficially, *M. Donnell-Smithii* may be distinguished from *M. tubiflora,* with which it is most likely to be confused, by means of its secund inflorescence and somewhat broader foliage. Technical details of the reproductive organs also vary. The species is evidently widespread in Guatemala, where it is a liana of mountain forests, frequenting altitudes of 1000 to 2500 meters.

Mandevilla platydactyla Woodson, sp. nov., suffruticosa volubilis; ramulis teretibus gracilibus juventate ferrugineo-tomentulosis tandem glabratis maturitate lignosis in longitudinem leviter striatis; foliis oppositis breviter petiolatis membranaceis obovato-oblongis apice abrupte acuminatis basi cuneatis obscure angusteque cordatis plerisque 5–10 cm. longis 2.5–5.0 cm. latis supra minute hispidulis nervo medio basi pluriglandulosis subtus pallidioribus praecipue in nervis venisque dense ferrugineo-tomentosis; petiolis 0.2–0.4 cm. longis ut in pagina ventrali folii vestitis; inflorescentiis racemosis lateralibus alternatis 10–25-floris; pedunculo foliis subaequante ut in ramulis vestito; pedicellis laxis plus minusve reflexis 0.8–1.0 cm. longis; bracteis oblongis acuminatis 0.3–0.6 cm. longis scariaceis sparse pilosis; calycis laciniis majusculis obovato-oblongis breviter acuminatis 0.75–1.0

cm. longis scariaceis (ante exsiccationem plus minusve coloratis ?) extus ferrugineo-puberulis intus basi squamellas multas dentiformes munitis; corollae (in sicco aurantiacae) salverformis tubo cylindrico 1.25–1.5 cm. longo basi ca. 0.3 cm. diametro metiente supra medium constricto ibique staminigero faucibus paulo ampliatis lobis oblique ovato-oblongis acutiusculis patentibus 0.4 cm. longis; antheris anguste oblongis basi truncate auriculatis 0.4 cm. longis; ovariis ovoideis apice abrupte constrictis 0.4–0.5 cm. longis pilosulis; stigmate proprio ca. 0.1 cm. longo apiculis subaequante; nectarii glandulis ovoideis plus minusve connatis ovariis subaequantibus; folliculis ignotis.—Mexico: Hidalgo (?): Tolapa, June, 1842. *F. M. Liebmann 11986* (Herbarium, Botanical Museum of Copenhagen, type, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

This species is one of the most striking of the Mexican representatives of the subgenus *Eumandevilla.* Because of its salverform corolla with conspicuous, spreading limb, and stamens inserted somewhat above midway within the tube, it is thought to be most closely allied to the series of species centering about *M. tubiflora, M. acutiloba,* and *M. Donnell-Smithii,* but differs from all in the showy development of the calyx, the lobes of which are broadly laminate and probably somewhat tinted in the living condition.

Mandevilla Rosana (Donn.-Sm.) Woodson, n. comb.

Echites Rosana Donn.-Sm. Bot. Gaz. **40:** 6. 1905.

At present known only from the type locality in Guatemala, this species differs from *M. acutiloba,* which might be regarded as its nearest congener, in the insertion of the stamens almost exactly midway within the corolla-tube, in the ovate lobes of the corolla, and in the somewhat rounded anther-lobes.

Mandevilla scorpioidea Woodson, sp. nov., suffruticosa volubilis; ramis teretibus gracilibus dense hirtellis; foliis oppositis longiuscule petiolatis membranaceis ovato-oblongis cordatis apice acuminatis 5–12 cm. longis 2.0–5.5 cm. latis supra hispidulis nervo medio basi pluriglandulosis subtus vix pallidioribus leviter puberulis; petiolis 0.5–1.0 cm. longis minute hirtellis; inflores-

centiis racemosis lateralibus alternatis 20–30-floris; pedunculo folia bis terve superante ut in ramis vestito; pedicellis sparsis subsecundis 0.75–1.0 cm. longis; bracteis linearibus 0.5–0.7 cm. longis pilosulis; calycis laciniis ovato-lanceolatis longe acuminatis 0.4–0.5 cm. longis scariaceis extus minute puberulo-papillatis intus pluriglandulosis; corollae (flavidae ?) salverformis tubo cylindrico 1.5 cm. longo basi ca. 0.15 cm. diametro metiente circa medium vel inferius staminigero deinde paulo dilatato fauces versus parum attenuato lobis oblique ovatis obtusiusculis patentibus 0.4–0.5 cm. longis; antheris lanceolatis basi rotundiuscule auriculatis 0.4 cm. longis; ovariis ovoideis apice abrupte constrictis ca. 0.1 cm. longis glabris; stigmate proprio ca. 0.1 cm. longo apiculis ca. ⅓ breviore; nectarii glandulis oblongoideis distinctis ovariis aequantibus; folliculis ignotis.—MEXICO: Chiapas: Cerro del Boqueron, June, 1914. *C. A. Purpus 7274* (Mo. Bot. Garden Herbarium, TYPE).

A species of very distinct aspect due to the long, subsecund inflorescence. The insertion of the stamens about midway within the corolla-tube appears to indicate a closer relationship to *M. Rosana* than to any other species at present known from Mexico or Central America.

Mandevilla scutifolia Woodson, sp. nov., suffruticosa volubilis; ramulis teretibus gracillimis minute puberulis; foliis oppositis petiolatis membranaceis late ovato-oblongis apice breviter acuminatis mucronulatis basi rotundatis obsolete cordatis 2–5 cm. longis 1.5–3.0 cm. latis supra minute puberulis nervo medio basi pluriglandulosis subtus vix pallidioribus in nervis laxe barbatis; petiolis 1.0–1.25 cm. longis minutissime puberulo-incanis; inflorescentiis racemosis lateralibus alternatis 3–10-floris; pedunculo foliis subaequante dimidia parte inferiore sterili deinde florifero ut in ramulis vestito; pedicellis laxis 0.75–1.0 cm. longis; bracteis ovato-oblongis acuminatis 0.3–0.4 cm. longis scariaceis; calycis laciniis ovatis acutiusculis 0.3 cm. longis scariaceis extus minute denseque puberulis intus basi in marginibus squamellas 3–4 flagelliformes munitis; corollae (gilvae) salverformis tubo gracile cylindrico 1 cm. longo basi ca. 0.1 cm. diametro metiente circa medium staminigero faucibus paulo ampliatis lobis oblique obo-

vato-reniformibus obtusiusculis patentibus 0.5 cm. longis; antheris oblongo-lanceolatis basi truncatis haud auriculatis 0.35 cm. longis; ovariis oblongo-ovoideis apice gradatim constrictis 0.1 cm. longis omnino glabris; stigmate proprio 0.2 cm. longo apicula terminalia ca. bis superante; nectarii glandulis ovoideis compressis truncatis plus minusve connatis ovariis dimidio aequantibus; folliculis ignotis.—PERU: "Andes of Saragosa," date lacking. *W. Lobbs. n.* (Herbarium Kew., TYPE, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

While its affinities are clearly with the other South American species of *Eumandevilla* bearing salverform corollas, the distinct structure of the inflorescence, which might almost be described as subumbellate, as well as the size and shape of the corolla, entitles *M. scutifolia* to a unique position, without any very closely neighboring congeners. The species is known at present only from the type collection.

Mandevilla riparia (HBK.) Woodson, n. comb.

Echites riparia HBK. Nov. Gen. **3**: 214. 1818.

The generic affinities of this plant, collected in recent years, as originally, in the valley of the Magdalena River of Colombia, are obviously with *Mandevilla* by reason of the glandular foliage, simple, racemose inflorescence, and umbraculiform stigma. It differs from *M. montana* (HBK.) Mgf. chiefly in the longer, more slender corolla-tube with orbicular-ovate lobes, and in the shorter calyx.

Mandevilla Jamesonii Woodson, sp. nov., suffruticosa volubilis; ramulis teretibus crassiusculis juventate minute puberulis mox glabratis; foliis oppositis petiolatis membranaceis late ovato-oblongis apice breviter acuminatis basi rotundatis et obsolete cordatis 3–6 cm. longis 2–4 cm. latis supra subpuberulis glabratisve nervo medio basi pluriglandulosis subtus pallidioribus molliter puberulis; petiolis 0.75–1.0 cm. longis laxe pilosulis; inflorescentiis racemosis lateralibus vel subterminalibus alternatis ca. 6-floris; pedunculo puberulo foliis subaequante; pedicellis 1.25 cm. longis laxis; bracteis lanceolatis ca. 0.2 cm. longis scariaceis; calycis laciniis lanceolatis acuminatis 0.4–0.5 cm. longis

scariaceis extus puberulis intus basi in marginibus squamellas 4–5 flagelliformes instructis; corollae (ut videtur gilvae) salverformis tubo gracile cylindrico 2 cm. longo basi ca. 0.15 cm. diametro metiente circa medium staminigero et paulo dilatato lobis oblique obovatis dolabriformibusque apice rotundatis patulis tubo subaequantibus; antheris anguste oblongo-lanceolatis 0.5–0.6 cm. longis basi haud auriculatis; ovariis oblongo-ovoideis apice in stylo gradatim constrictis 0.2 cm. longis glabris; stigmate proprio ca. 0.25 cm. longo apiculis subaequantibus; nectarii glandulis ovato-quadratis plus minusve connatis ovariis ca. duplo brevioribus; folliculis ignotis.—ECUADOR: "hedges, Loxa," date lacking. *W. Jameson 153* (Herbarium Kew, TYPE, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

Although closely allied to the other South American species of the *montana* plexus of *Eumandevilla*, *M. Jamesonii* is conspicuous because of the magnitude of the flowers and the elaborate corolline limb.

Mandevilla subsessilis (A. DC.) Woodson, n. comb.

Echites subsessilis A. DC. in DC. Prodr. **8**: 451. 1844.

This is certainly one of the most peculiar species of *Mandevilla*. Its unusually large, broadly obovate, sessile or subsessile, amplexicaul leaves, and clumsy, obovate-reniform calyx-lobes are quite different from those of any other species of the genus known at present. Technical details, however, prove it correctly referable to the group of South American species of *Eumandevilla* centering about *M. montana* (HBK.) Mgf., thus fortunately judging the doubtful data "*Mexico ? Peruvia ?*" upon Pavon's original specimen in the Herbier Boissier. The plant has evidently been collected but once.

Mandevilla fragilis Woodson, sp. nov., suffruticosa volubilis; ramis teretibus gracilissimis juventate minute sparseque puberulis mox glabratis; foliis oppositis petiolatis tenuiter membranaceis anguste oblongo-lanceolatis acuminatis obsolete cordatis 3–7 cm. longis 0.75–1.5 cm. latis supra glabris nervo medio basi pauciglandulosis subtus glaucis; petiolis 0.75–1.25 cm. longis omnino glabris; inflorescentiis racemosis lateralibus alternatis 3–5-floris;

pedunculo glabro foliis paulo breviore; pedicellis laxis 0.75–1.0 cm. longis; bracteis minimis scariaceis; calycis laciniis ovato-oblongis acutiusculis 0.1 cm. longis scariaceis extus glabris intus basi in marginibus squamellam flagelliformem instructis; corollae (flavidae plus minusve roseatae ?) fragilis salverformis tubo cylindrico gracilissimo 1.25 cm. longo basi ca. 0.1 cm. diametro metiente circa medium staminigero sed vix dilatato, lobis inaequilateraliter ovato-oblongis acutiusculis valde patentibus tubo vix aequantibus; antheris anguste oblongis basi truncatis haud auriculatis 0.3 cm. longis; ovariis oblongo-ovoideis ca. 0.05 cm. longis apice in stylo capillaceo gradatim attenuatis omnino glabris; stigmate proprio 0.2 cm. longo apicula sterilia ca. bis superante; nectarii glandulis ovoideis ovariis vix aequantibus; folliculis ignotis.—BOLIVIA: exact locality and date lacking. *M. Bang 2271* (Herbarium Kew., TYPE, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

This delicate and exceedingly graceful species is peculiar because of the solitary squamellae alternating with the lobes of the calyx. In its habit, it has no counterpart in the genus as at present understood.

Mandevilla pycnantha (Steud.) Woodson, n. comb.

Echites densiflora Pohl, ex Stadelm. Flora **24**: Beibl. I. 56. 1841, not Blume.

Echites pycnantha Steud. Nom. ed. 2. **1**: 540. 1841.

Heterothrix pycnantha (Steud.) Muell.-Arg. in Martius, Fl. Bras. **6**[1]: 133. 1860.

Apparently only two collections have ever been made of this puzzling species: one bearing flowers only, by Riedel (no. *985*) at the Serra da Lapa, southern Brazil, and represented in the herbaria of the Jardin de l'Etat, Brussels, the Royal Botanic Gardens, Kew, the Botanical Museum, Vienna, and the Gray Herbarium of Harvard University, Cambridge; and another, bearing fruit only, by Pohl at the Serra do Pinheiro, in the state of Minas Geraes, Brazil, and represented at Brussels and Vienna only.

Mueller-Argoviensis regarded the plants as constituting a monotypic genus, *Heterothrix*, separating them from *Amblyan-*

thera Muell.-Arg., not Blume (antedated by *Mandevilla* Lindl.), upon the supposition of a seminal coma consisting of two distinct series of hairs. When examining the fruiting specimens collected by Pohl, the writer was disappointed to find the follicles nearly empty, with only the tangled masses of the yellow coma twisted and matted among the several mericarps. After rather laborious extraction of numerous strands, some of which were fortunately yet attached to seeds, it has been assumed that the coma of *M. pycnantha* is probably similar to that of all other known Echitoideae in being homogeneous. The observation of Mueller is thought to have been affected by the fragmentary and grossly distorted material available for his study. With its only generic character held in serious question, therefore, the species has been placed provisionally within *Mandevilla* subgen. *Eumandevilla* with the technical criteria of which it appears to coincide in every essential respect.

Mandevilla cercophylla Woodson, sp. nov., suffruticosa volubilis omnino glabra; ramulis subteretibus gracilibus; foliis oppositis longiuscule petiolatis subcoriaceis obovato-oblongis apice abrupte acuminatis subcaudatis basi gradatim angustatis et obsolete auriculatis 3–6 cm. longis 1–3 cm. latis nervo medio basi ventro pauciglandulifero nervis secundariis fere horizontalibus haud arcuatis distantibus prope marginem junctis; petiolo 0.5 cm. longo; inflorescentiis racemosis lateralibus alternatis 8–17-floris; pedunculo flexuoso foliis subaequante; pedicellis laxis 0.75–1.0 cm. longis; bracteis ovatis minimis scariaceis; calycis laciniis ovato-trigonalibus ca. 0.1 cm. longis scariaceis intus basi squamellas multas flagelliformes gerentibus; corollae salverformis colore ignotae tubo cylindrico gracillimo 1.25 cm. longo basi ca. 0.1 cm. diametro metiente circa medium staminigero sed haud distincte dilatato lobis oblique ovato-oblongis acutiusculis (erectis vel vix patentibus ?) 0.5 cm. longis; antheris lanceolatis basi truncatis haud auriculatis 0.45 cm. longis; ovariis oblongo-ovoideis 0.15 cm. longis apice in stylo gracillimo gradatim productis; stigmate proprio 0.15 cm. longo apiculis terminalibus vix aequante; nectarii glandulis oblongo-ovoideis basi connatis ovariis dimidio aequantibus; folliculis maturis ignotis.—Peru: Casapi, date lacking.

A. Matthews 1978 (Herbarium Kew., TYPE, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

Probably as closely allied to *M. brachyloba* (Muell.-Arg.) K. Sch. as to any other species known at present, because of the short corolla-lobes which are thought to have been erect or essentially so in the living condition. The corolla is without the glandular papillae characteristic of that of *M. brachyloba,* however, and consequently does not blacken upon desiccation as does the corolla of the latter species. The leaves, moreover, are subcoriaceous, caudate-acuminate, obscurely auriculate, and are characterized by horizontal secondary venation, in all quite dissimilar to the foliage of *M. brachyloba.* The plant has evidently been collected but once.

Mandevilla erecta (Vell.) Woodson, n. comb.

Echites erecta Vell. Fl. Flum. 113. 1830; Icon. **3:** *pl. 45.* 1827.

Laseguea erecta (Vell.) Muell.-Arg. in Martius, Fl. Bras. **6[1]:** 135. 1860.

Originally established with two species of dubious distinction, the genus *Laseguea* appears to differ from most other American Echitoideae in the conspicuous, brushy inflorescence, bearing subtubular corollas with small, erect lobes scarcely surpassing the curiously foliaceous bracts and calyx-lobes. The plants referred to *Laseguea* are surely very conspicuous, and have been popular with both collectors and systematists for that reason.

Mueller-Argoviensis was evidently hard put to assure the integrity of the genus *Laseguea* by ascribing to it more precise morphological criteria than those of vegetative habit, and made the observation of a dissimilar seminal coma as he had interpreted in the case of the genus *Heterothrix.* In spite of Mueller's definition of the coma, however, the foliaceous bracts and calyx-lobes and salverform corolla, accompanied by reasonably broad foliage, have remained the real distinction of the genus as popularly conceived.

These features, supposedly distinctive of *Laseguea,* were eventually proved invalid by John Miers, in an unintentional *reductio ad absurdum,* by applying the name to every species,

from Mexico to southern Brazil, which could possibly be so interpreted by the characters of the inflorescence alone. K. Schumann, in Engl. & Prantl, Nat. Pflanzenfam. 4^2: 171. 1895, may have criticized rather unjustly, therefore, when he wrote: "Auch in dieser Gattung [*Laseguea*] hat Miers viel mehr Arten aufgezählt; ich möchte fast glauben, dass er alle Echitoideae mit grossen Kelchen mehr dem Zufall als einem bestimmten Princip nach unter Laseguea und Rhodocalyx aufgeteilt hat," for he himself was unable to suggest more definite criteria.

When examined critically, the distinguishing characters of *Laseguea* quickly resolve into a combination of features present in numerous species of *Mandevilla.* The corolla of the former, which is tubular or subtubular with an inconspicuous, erect limb, occurs in almost exact proportions in *M. brachyloba* and *M. cercophylla,* also of South America. As in the former, the exterior of the corolla is densely studded with minute, glandular papillae; but as in the latter, desiccation is not accompanied by blackening.

The conspicuous calyx-lobes and bracts of *Laseguea,* moreover, are equalled or even surpassed in magnitude by those of several species of *Mandevilla,* a particular instance of timely note being *M. platydactyla* newly described in a preceding paragraph of these records. The bracts of several Mandevillas, in particular, are even more striking than those of *Laseguea,* as, for example, those of *M. villosa* (Miers) Woodson, *M. bracteata* (HBK.) K. Sch., and *M. javitensis* (HBK.) K. Sch. When considered independently, the essential organs of the flower and foliage are all indistinguishable from those of *Mandevilla* subgen. *Eumandevilla,* to which *Laseguea* with its two valid species is relegated. Abundant fruiting material again has failed to reveal the foundation of Mueller's observation of a double coma.

Mandevilla Pentlandiana (A. DC.) Woodson, n. comb.

Parsonsia ? bracteata Hook. & Arn. in Hook. Jour. Bot. **1**: 287. 1834.

Laseguea Pentlandiana A. DC. Ann. Sci. Nat. Bot. III. **1**: 262. 1844.

Laseguea Hookeri Muell.-Arg. in Martius, Fl. Bras. 6^1: 136. 1860.

Laseguea bracteata (Hook. & Arn.) K. Sch. in Engl. & Prantl, Nat. Pflanzenfam. 4^2: 171. 1895.

Laseguea Mandoni Britton, ex Rusby, Mem. Torrey Bot. Club **4**: 220. 1895.

One may question very justly the distinction between *M. Pentlandiana* and *M. erecta*. The former is composed apparently of rather extensive sylvan lianas of Bolivia and northern Argentina, and is characterized by distinctly petiolate, ovate-cordate foliage. On the other hand, *M. erecta* is represented by more or less erect, suffrutescent undershrubs with nearly sessile, orbicular-ovate leaves, apparently being found only on the campos of Paraguay and adjoining Brazil and Uruguay. As a matter of fact, the delimitation of Apocynaceous lianas and undershrubs is not particularly precise, especially among the Echitoideae of southeastern South America; and with additional study and accumulation of specimens, the two species may be found to merge.

The type specimen of *Laseguea Pentlandiana* A. DC. was not found for examination in the Herbier Boissier as indicated by de Candolle, but the original description coincides well with plants examined in the course of these studies. It is interesting to note, furthermore, that according to de Candolle the specimen collected by Pentland upon which the species was based bears the data "*In Bolivia, ad Illimani.*" *Buchtien 250*, occurring in several of the principal herbaria of America and Europe, was also collected in Bolivia, bearing the data "*Cotana am Illimani,*" and may therefore be viewed as virtually a topotype. The earlier specific name of Hooker and Arnott cannot be used in this combination because of the pre-existence of *M. bracteata* (HBK.) K. Sch.

Mandevilla torosa (Jacq.) Woodson, n. comb.

Echites torosa Jacq. Enum. Syst. Pl. Carib. 13. 1760.

Echites torulosa L. Sp. Pl. ed. 2. 307. 1762.

Echites torosa Jacq. var. *Brownei* A. DC. in DC. Prodr. **8**: 449. 1844.

Amblyanthera torosa (Jacq.) Muell.-Arg. Linnaea **30**: 446. 1860.

Echites Brownei (A. DC.) Muell.-Arg. loc. cit. 1860.

Mesechites torulosa (L.) Miers, Apoc. So. Am. 229. 1878.
Mesechites Brownei (A. DC.) Miers, loc. cit. 232. 1878.

The affinities of this species were recognized by Mueller, but *Amblyanthera* is a generic name not only antedated by *Mandevilla* Lindl., but invalidated by a previous homonym. The plant is a native of Jamaica where it constitutes a very clear-cut and uniform species and is the only representative of the genus in the Antilles. It is also found in Yucatan, but there becomes rather aggregate and variable, probably through hybridization with the closely related *M. Karwinskii* (Muell.-Arg.) Hemsl. A distribution common to Jamaica and northern Yucatan is not infrequent among the Apocynaceae.

Mandevilla mexicana (Muell.-Arg.) Woodson, n. comb.
Amblyanthera mexicana Muell.-Arg. Linnaea **30**: 424. 1860.
Echites mexicana (Muell.-Arg.) Miers, Apoc. So. Am. 205. 1878.
Echites Smithii Greenm. Proc. Am. Acad. **40**:29. 1904.

Closely related to *M. foliosa* (Muell.-Arg.) Hemsl., and differing chiefly in the size and indument of the foliage.

Mandevilla apocynifolia (A. Gray) Woodson, n. comb.
Echites (*Amblyanthera ?*) *apocynifolia* A. Gray, Proc. Am. Acad. **22**: 435. 1887.

That Dr. Gray suspected the generic affinities of this species is indicated by his dubious, parenthetical reference to the invalid genus *Amblyanthera* Muell.-Arg. *M. apocynifolia,* together with *M. mexicana, M. foliosa* (Muell.-Arg.) Hemsl., and *M. Karwinskii* (Muell.-Arg.) Hemsl., constitutes a conspicuous group, probably deserving of sectional rank, which is characterized by an extremely suffrutescent, virtually herbaceous, erect habit. The species of this group intergrade through occasionally twining individuals of *M. Karwinskii* and the typically volubile *M. torosa* to the liana habit characteristic of the bulk of species of the genus.

Mandevilla equatorialis Woodson, sp. nov., suffruticosa volubilis; ramulis teretibus gracillimis juventate minute puberulis tandem glabratis; foliis oppositis petiolatis rigide membranaceis

ovato-oblongis breviter acuminatis obscure lateque cordatis plerisque 2–5 cm. longis 1.0–1.25 cm. latis supra minute puberulis mox glabratis nervo medio basi pauciglanduliferis subtus pallidioribus et dense tomentellis; petiolis 0.3–0.7 cm. longis puberulis; inflorescentiis racemosis lateralibus vel subterminalibus alternatis 8–14-floris; pedunculo puberulo folia ca. duplo superante; pedicellis laxis 0.4 cm. longis post maturitatem paulo accrescentibus; bracteis lanceolatis 0.2–0.3 cm. longis scariaceis; calycis laciniis lanceolatis acuminatis 0.2 cm. longis scariaceis extus minute puberulo-papillatis intus basi in marginibus squamellas 3–5 flagelliformes gerentibus; corollae (gilvae vel purpurascentis ?) infundibuliformis extus minute puberulae tubo proprio cylindrico brevissimo 0.2 cm. longo basi ca. 0.1 cm. diametro metiente ad apicem staminigero deinde angustiuscule conico-dilatato faucibus 0.5–0.7 cm. longis ostio ca. 0.4 cm. diametro metiente lobis oblique ovato-lanceolatis acuminatis 0.3 cm. longis; antheris anguste oblongis basi truncatis haud auriculatis 0.35 cm. longis; ovariis ovoideis ca. 0.1 cm. longis apice in stylo gracili gradatim attenuatis glabris; stigmate proprio ca. 0.15 cm. longo apiculis sterilibus vix aequante; nectarii glandulis ovoideo-quadratis truncatis basi connatis ovariis vix dimidio aequantibus; folliculis maturis ignotis.—Ecuador: vicinity of Tablon de Oña, Sept. 27, 1918. *J. N. Rose, A. Pachano & G. Rose 23029* (U. S. National Herbarium, type, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

Without any particularly manifest affinities. Although details of the reproductive apparatus undoubtedly prove the species coherent with the other South American species of *Eumandevilla*, the proportions of the corolla are reminiscent of those of *M. convolvulacea* (A. DC.) Hemsl. of southern Mexico.

Mandevilla glandulosa (R. & P.) Woodson, n. comb.

Echites glandulosa R. & P. Fl. Peruv. **2**: 19. *pl. 135*. 1799.

Prestonia Peruviana Spreng. Syst. **1**: 637. 1825.

Haemadictyon glandulosum (R. & P.) A. DC. in DC. Prodr. **8**: 427. 1844.

Odontadenia glandulosa (R. & P.) K. Sch. in Engl. & Prantl, Nat. Pflanzenfam. **4**^{2}: 169. 1895.

As far as may be ascertained, the original specimen of *Echites glandulosa* collected by Pavon does not exist. The species was unknown both to A. de Candolle and to Miers except as represented in the excellent illustration accompanying Ruiz's description. Consequently its generic status has been somewhat uncertain.

Recently, Weberbauer (no. *4384* in Hb. Berol.) has encountered in flower, as has also Macbride (no. *3730* in Hb. Field Museum) in fruit, a plant almost precisely similar to that illustrated by Ruiz, and for the first time direct evidence may be utilized in interpreting the vexatious question concerning its generic affinity. K. Schumann was impressed by the fact that the five hypogynous nectaries of Weberbauer's specimen are somewhat concrescent and that the inflorescence is opposite, and thus concluded that it should be included within *Odontadenia* Benth., overlooking the glandular emergences at the base of the midrib upon the ventral surface of the foliage, the obscurely auriculate anthers, and the pentagonal-umbraculiform stigma, which necessitate its inclusion within *Mandevilla* Lindl. subgen. *Eumandevilla*.

The only feature which the species in question does not have in common with the other known species of *Mandevilla* is the opposite disposition of the axillary racemes. That phenomenon should not be regarded as of great importance, however, as the characteristic alternate branching has been observed to become opposite in cases of previous injury, and in many instances dormant or abortive branch buds may be observed opposite the functional branch or inflorescence. Furthermore, opposite branching has been found normally at the lower nodes of virtually all species, and may logically be viewed as a primitive structural feature.

Mandevilla Bridgesii (Muell.-Arg.) Woodson, n. comb.

Amblyanthera Bridgesii Muell.-Arg. Linnaea **30**: 420. 1860.

Mandevilla Mandoni Britton, Bull. Torrey Bot. Club **25**: 496. 1898.

Mandevilla Bangii Rusby, Bull. N. Y. Bot. Gard. **4**: 315. 1907.

A species much collected in Bolivia in recent years. Most closely related to the following:

Mandevilla laxa (R. & P.) Woodson, n. comb.

Echites laxa R. & P. Fl. Peruv. **2**: 19. *pl. 134.* 1799.

Mandevilla suaveolens Lindl. Bot. Reg. **3**: 7. *pl. 7.* 1840.

Echites suaveolens (Lindl.) A. DC. in DC. Prodr. **8**: 452. 1844, not Mart. & Gal.

Amblyanthera suaveolens (Lindl.) Muell.-Arg. Linnaea **30**: 447. 1860.

Mandevilla Tweediana Gadeceau & Stapf, Bull. Soc. Sci. Ouest Fr. III. **3**: 2. 1913.

Although it has been impossible to locate an authentic specimen of Ruiz's species, there can be little doubt that his illustration and that of Lindley, accompanied in the latter instance by an indubitable description of the familiar plant of horticulture, are essentially conspecific. Unfortunately, *M. suaveolens*, which is displaced by the earlier name, is the type of the genus *Mandevilla* Lindl.

Mandevilla grata Woodson, sp. nov., suffruticosa volubilis; ramulis teretibus gracillimis juventate minute puberulo-papillatis tandem glabratis; foliis oppositis longiuscule petiolatis membranaceis ovato-cordatis apice breviter acuteque acuminatis 7–12 cm. longis 5–9 cm. latis supra juventate minute puberulo-papillatis mox glabratis nervo medio basi pauciglanduliferis subtus vix pallidioribus praecipue in nervis venisque laxe villosulis; petiolis 2.0–3.5 cm. longis glabratis; inflorescentiis racemosis lateralibus alternatis folia vix duplo superantibus 4–12-floris; pedunculo parte circa dimidio inferiore sterili deinde laxe florifero glabro; pedicellis 1.5–2.0 cm. longis; bracteis lanceolatis acuminatis 0.5–1.0 cm. longis subfoliaceis; calycis laciniis oblongo-linearibus acuminatis 1 cm. longis subfoliaceis extus glabris intus basi in marginibus squamellas 3–5 denticulatas gerentibus; corollae (ut videtur albae dilute flavescentis) infundibuliformis tubo proprio cylindrico breviusculo 1 cm. longo basi ca. 0.3 cm. diametro metiente ad apicem staminigero ibique dilatato faucibus tubuloso-conicis tubo proprio aequantibus vel eum paulo superantibus ostio ca. 0.4–0.5 cm. diametro metiente lobis inaequilateraliter ovatis vix dolabriformibus 0.5–0.7 cm. longis patulis; antheris anguste oblongis basi obsolete truncateque auriculatis 0.8–0.9 cm. longis; ovariis oblongoideis ca. 0.2 cm. longis apice in stylo

crassiusculo gradatim attenuatis glabris; stigmate proprio 0.3 cm. longo apiculis inconspicuis; nectarii glandulis ovoideo-reniformibus truncatis plus minusve connatis ovariis dimidio vix aequantibus; folliculis ignotis.—ARGENTINA: Tucuman: Muñecas, March 5, 1923. *S. Venturi 1769a* (Mo. Bot. Garden Herbarium, TYPE).

M. grata finds its closest affinity with the Bolivian *M. Bridgesii*. It is distinct by reason of practically every dimension of the corolla, which is much smaller in general, with proportionally longer proper tube and conspicuously shorter lobes of a different shape and position. The pubescence of the foliage, also, although of the same nature as that of the latter species as distinguished from that of the closely neighboring *M. laxa*, is very much sparser and finer, being scarcely perceptible to the unaided eye. The general shape of the leaves, as well as their venation, together with the long, subfoliaceous calyx-lobes and subtubular corolla, serves to impress one with the congenericity of *Mandevilla* Lindl. and the Candollean *Laseguea*.

Mandevilla albo-viridis (Rusby) Woodson, n. comb.

Dipladenia alba-viridis Rusby, Descr. So. Am. Pl. 86. 1920.

There can be little doubt that this plant is congeneric with such species as *M. grata*, *M. Bridgesii*, *M. glandulosa*, and *M. laxa*. The inflorescence of the single specimen constituting the type (*H. H. Smith 1904* in Hb. N. Y. Bot. Garden) is too depauperate to permit thorough examination of the nectaries, which form the sole and all too frequently untrustworthy distinction between *Mandevilla* Lindl. and *Dipladenia* A. DC., but a re-examination of the original dissection, fortunately preserved, discloses that a slip of the needle must have caused an untoward amputation of three of five normal, hypogynous nectaries, thereupon transforming the flower to that of a *Dipladenia!* The occurrence of *M. albo-viridis* in northern Colombia is a considerably boreal extension of the distribution of the typical section of *Eumandevilla*, heretofore confined to Bolivia and adjacent Peru and Argentina.

Mandevilla subsagittata (R. & P.) Woodson, n. comb.

Echites subsagittata R. & P. Fl. Peruv. **2**: 19. 1799.

Echites mucronata R. & S. Syst. **4**: 796. 1819.

Echites Guayaquilensis Benth. Pl. Hartw. 119. 1839.
Echites microcalyx A. DC. in DC. Prodr. **8**: 456. 1844.
Amblyanthera microcalyx (A. DC.) Muell.-Arg. Linnaea **30**: 425. 1860.

This extremely variable and abundant species of Central and northern South America is represented here by only a few of the more familiar names which must be ascribed to it as synonyms. Mueller-Argoviensis was quite aware of the affinities of *E. microcalyx*, which he transferred to his invalid genus *Amblyanthera*, noting in the case of the earlier *E. subsagittata* "*est Amblyantherae spec. forte ab A. microcalyce non diversa*" (loc. cit. 453. 1860). A specimen collected by Pavon at Guayaquil and at present deposited in the Herbier Boissier should probably be considered as authentic.

Mandevilla villosa (Miers) Woodson, n. comb.
Laseguea villosa Miers, Apoc. So. Am. 250. 1878.
Echites comosa O. Ktze. Rev. Gen. **2**: 414. 1891.

Differing from *M. subsagittata* chiefly in the conspicuous, foliaceous, or petaloid bracts, and for that reason placed within the genus *Laseguea* by Miers.

Mandevilla Fendleri (Muell.-Arg.) Woodson, n. comb.
Amblyanthera Fendleri Muell.-Arg. Linnaea **30**: 417. 1860.

The publication of this species under the pre-empted and antedated name *Amblyanthera* requires a recombination under *Mandevilla*, as also is the case of the immediately following:

Mandevilla Schlimii (Muell.-Arg.) Woodson, n. comb.
Amblyanthera Schlimii Muell.-Arg. Linnaea **30**: 419. 1860.

Mandevilla symphitocarpa (G. F. W. Mey.) Woodson, n. comb.
Echites symphitocarpa G. F. W. Mey. Prim. Fl. Esseq. 132. 1818.

Differs from *M. scabra* (R. & S.) K. Sch. chiefly in the generally larger floral organs and in the lack of a vegetative indument. Apparently confined to Trinidad and the Guianas.

Mandevilla Trianae Woodson, sp. nov., suffruticosa volubilis; ramulis teretibus gracillimis molliter puberulo-hirtellis rarius

glabratis; foliis oppositis breviter petiolatis membranaceis late ovato-lanceolatis apice acutiusculis basi gradatim rotundatis et obsolete cordatis plerisque 6–12 cm. longis 2–4 cm. latis supra minute puberulis glabratisve nervo medio in longitudinem pluriglandulosis subtus puberulis; petiolis 0.3–0.6 cm. longis ut in folio vestitis; inflorescentiis racemosis lateralibus alternatis; pedunculo puberulo folia vix superante 6–10-florifero; pedicellis laxis 0.4–0.6 cm. longis; calycis laciniis lanceolatis acuminatis 0.1–0.2 cm. longis extus minute puberulis intus basi squamellam parvam deltoideam minute denticulatam gerentibus; corollae infundibuliformis tubo proprio breviuscule cylindrico 1.75–2.0 cm. longo basi ca. 0.1 cm. diametro metiente ad apicem staminigero ibique dilatato faucibus conico-cylindricis 1.5–1.75 cm. longis ostio ca. 0.75 cm. diametro metiente lobis oblique obovatis acutiusculis faucibus vix aequantibus evidenter plus minusve patentibus; antheris anguste elliptico-oblongis basi obscure auriculatis 0.4 cm. longis; ovariis oblongoideis 0.15 cm. longis apice plus minusve gradatim attenuatis minute puberulis; stigmate proprio ca. 0.2 cm. longo apicula terminalia quadruplo superante; nectarii glandulis oblongo-ovoideis distinctis ovariis ca. dimidio brevioribus; folliculis ignotis.—COLOMBIA: Choco: "alt. 150 m., April, 1853." *J. J. Triana 3409* (Herbarium British Museum, TYPE, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

Evidently allied to *M. Schlimii* because of the tubular or cylindrical corolla-throat, but differing in the larger leaves of a distinct shape, as well as in the dimensions of the flowers. It appears to be a species limited to the northern Pacific Coastal Zone of South America, having been collected by Pittier (no. *520* in U. S. Nat. Hb.) in the state of Cauca, Colombia, and by Andrè (no. *3590* in Hb. Kew.) upon the western slope of the Ecuadorian Andes.

Mandevilla subpaniculata Woodson, n. name

Echites macrophylla A. Zahlbr. Ann. K.K. Naturh. Hofmus. Wien **7**: 5. 1892, not HBK.

The most striking feature displayed by this species is the complete lack of the usual nectaries surrounding the ovary. In view of the great variability of this character in both *Mandevilla* Lindl.

and *Dipladenia* A. DC., it has been considered advisable to refer the species to the former rather than to establish a new genus for its inclusion.

Mandevilla sagittarii Woodson, sp. nov., suffruticosa volubilis; ramulis teretibus crassiusculis sparse ferrugineo-hispidulis; foliis oppositis longiuscule petiolatis membranaceis late oblongo-ellipticis apice abrupte acuminatis acute subcaudatis basi gradatim attenuatis et obscure cordatis 8–12 cm. longis 4–6 cm. latis supra sparse strigillosis nervo medio in longitudinem pluriglandulosis subtus dense tomentulosis; petiolis 1.5 cm. longis dense pilosulis; inflorescentiis racemosis lateralibus alternatis; pedunculo minute hispidulo 5–15-florifero foliis fere dimidio aequante; pedicellis 0.75 cm. longis post maturitatem parum accrescentibus; bracteis magnis ovatis caudato-acuminatis sessilibus 1.0–1.5 cm. longis laxe pilosulis rubidulo-coloratis; calycis laciniis linearo-lanceolatis acuminatis 0.75 cm. longis extus sparse minuteque pilosulis intus basi squamellam deltoideam apice indistincte denticulatam gerentibus; corollae infundibuliformis (ut dicitur dilute flavidulae) extus pilosulae tubo proprio longiuscule cylindrico paulo ventricoso 2.5 cm. longo basi ca. 0.2 cm. diametro metiente ad apicem staminigero ibique dilatato faucibus late tubulosis paulo inaequilateralibus 3 cm. longis ostio ca. 0.75 cm. diametro metiente lobis oblique lateque obovatis 1.5 cm. longis valde patentibus; antheris oblongo-ellipticis basi anguste obsoleteque auriculatis 0.35 cm. longis; ovariis ovoideis 0.2 cm. longis apice in stylo gracili gradatim angustatis glabris vel minutissime papillatis; stigmate proprio ca. 0.15 cm. longo apicula sterilia ter superante; nectarii glandulis subquadratis basi connatis ovariis dimidio aequantibus; folliculis obscure moniliformibus 12–15 cm. longis plus minusve falcatis hispidulo-strigillosis; seminibus subscaphiformibus 1 cm. longis como 2 cm. longo aurantiaco.—Colombia: Choco: between La Oveja and Quibdo, April 1–2, 1931. *W. A. Archer 1714* (U. S. National Herbarium, type, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

Without doubt closely related to *M. hirsuta* (A. Rich.) K. Sch., but differing markedly in the tubular corolla-throat which strongly resembles that of an *Odontadenia*.

Mandevilla Pavonii (A. DC.) Woodson, n. comb.

Echites hirsuta R. & P. Fl. Peruv. **2**: 19. *pl. 136.* 1799, not A. Rich.

Prestonia hirsuta (R. & P.) Spreng. Syst. **1**: 637. 1825.

Echites Pavonii A. DC. in DC. Prodr. **8**: 463. 1844.

The writer has been unable to locate Pavon's original specimen in the Herbier Boissier as indicated by de Candolle, but feels confident in making the above recombination upon the basis of the original illustration which agrees essentially with two collections recently made in eastern Peru by G. Klug (nos. *1288* & *57* in U. S. Nat. Hb.).

Mandevilla bogotensis (HBK.) Woodson, n. comb.

Echites Bogotensis HBK. Nov. Gen. **3**: 215. *pl. 243.* 1818.

Amblyanthera Bogotensis (HBK.) Muell.-Arg. Linnaea **30**: 452. 1860.

Anartia Bogotensis (HBK.) Miers, Apoc. So. Am. 82. 1878.

As in *M. subpaniculata,* the nectaries of this species are obsolete. In spite of this anomaly, however, Mueller was fully aware of the generic affinities of the plants, transferring them to his invalid genus *Amblyanthera.* The absence of the gynoecial nectaries, usually prominent features of the American species of Echitoideae, is presumably responsible alone for Miers's transfer of the species to *Anartia* Miers, a dubious segregate of the inclusive genus *Tabernaemontana* L.

Mandevilla polyantha K. Sch. in herb., suffruticosa volubilis; ramulis teretibus gracillimis pilosis; foliis oppositis longiuscule petiolatis membranaceis late ellipticis acuminatis obscure angusteque cordatis 7–12 cm. longis 3–6 cm. latis supra nitidulis nervo medio in longitudinem pilosulis et pluriglandulosis subtus pallidioribus praecipue in nervis venisque laxe puberulis; petiolis 1.0–1.5 cm. longis ut in ramulis vestitis; inflorescentiis racemosis lateralibus alternatis; pedunculo glaberrimo 20–35-florifero folia vix duplo superante; pedicellis subsecundis 1 cm. longis post maturitatem longe accrescentibus; bracteis linearibus scariaceis minimis; calycis laciniis late trigonalibus acutiusculis 0.1 cm. longis scariaceis extus dense puberulo-papillatis intus basi squa-

mellam deltoideam denticulatam gerentibus; corollae (viridoflavidulae ?) infundibuliformis extus glabrae tubo cylindrico ventricoso 1.0–1.25 cm. longo basi ca. 0.15 cm. diametro metiente ad apicem staminigero ibique dilatato faucibus conicis parum inaequilateralibus 1 cm. longis ostio ca. 0.5 cm. diametro metiente lobis oblique obovato-reniformibus 0.25 cm. longis valde patentibus; antheris cuneato-ellipticis basi angustissime auriculatis 0.3 cm. longis; ovariis oblongo-ovoideis 0.15 cm. longis omnino glabris; stigmate proprio 0.1 cm. longo apicula terminalia ca. ter superante; nectarii glandulis ovoideo-dentiformibus basi plus minusve connatis ovariis vix aequantibus; folliculis maturis ignotis.—PERU: Loreto: Yurimaguas, Aug., 1902. *E. Ule 6271* (Herbarium Bot. Gart. Berlin-Dahlem, TYPE, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

This interesting species, which more recently has been collected by Killip & Smith (no. *27579* in U. S. Nat. Hb.) in the same general locality as that of the type specimen, recalls to a certain extent the aspect of *M. Moritziana* of Venezuela, but differs in the smaller, more gibbous corolla, the inconspicuous, scarious bracts, and the indument of the vegetative parts. The species was noted as a *nomen nudum* in Engl. Bot. Jahrb. **40:** 403. 1908.

Mandevilla lancifolia Woodson, sp. nov., suffruticosa erecta altitudine ignota; ramis subteretibus vel plus minusve alatis juventate dense puberulo-papillatis tandem glabratis cortice griseo-brunneis; foliis oppositis brevissime petiolatis rigide membranaceis anguste linearo-lanceolatis 3–6 cm. longis 0.5–0.75 cm. latis omnino glabris nervo medio ventro in longitudinem inconspicue pauciglanduligero; petiolis 0.1–0.2 cm. longis glabris; inflorescentiis racemosis lateralibus alternatis; pedunculo glabro 1–7-floro foliis dimidio aequante; pedicellis 0.15 cm. longis; bracteis ovatis scariaceis minimis; calycis laciniis ovatis acutiusculis 0.15–0.2 cm. longis scariaceis extus glabris vel minutissime papillatis intus basi squamellam deltoideam profunde laciniatam gerentibus; corollae (ut videtur rubidulo-flavidulae) infundibuliformis tubo proprio gracile cylindrico 1 cm. longo basi ca. 0.1 cm. diametro metiente ad apicem staminigero ibique dilatato faucibus tubulo-conicis 1.5–2.0 cm. longis ostio ca. 0.5 cm. diametro

metiente lobis oblique obovatis obtusiusculis 1.5–2.0 cm. longis patulis; antheris oblongis basi obscure truncateque auriculatis 0.6 cm. longis; ovariis anguste oblongoideis apice in stylo capillaceo gradatim angustatis 0.2 cm. longis omnino glabris; stigmate proprio 0.2 cm. longo apiculis terminalibus vix manifestis; nectarii glandulis ovoideo-quadratis basi connatis ovariis quadruplo brevioribus; folliculis linearo-cylindricis acuminatis obscure articulatis laevibus 7–10 cm. longis; seminibus subscaphiformibus 0.5 cm. longis como 1.5 cm. longo aurantiaco.—VENEZUELA: Amazonas: Puerto Ayacucho: alt. 100 m., May, 1931. *E. G. Holt & E. R. Blake 780* (Mo. Bot. Garden Herbarium, TYPE, U. S. National Herbarium, duplicate).

A very distinct and showy species, conspicuous because of its dense, narrow foliage, and bright flowers, which was collected in 1854 by Richard Spruce (no. *3610* Hbb. Kew. & Vindob.) in approximately the same general locality on the upper Orinoco. *M. lancifolia* constitutes a rather unique addition to *Mandevilla* sect. *Eriadenia* Mgf., and appears to have no very definite affinities. From *M. Benthamii* (A. DC.) K. Sch., which it simulates very generally because of its narrow foliage, it may be distinguished by means of the opposite phyllotaxy and the narrower corolla-throat. *M. lancifolia* would also appear to attain a greater height than does the latter species.

Mandevilla anceps Woodson, sp. nov., suffruticosa erecta; ramulis crassiusculis distincte ancipibus juventate dense minuteque puberulis tandem glabratis; foliis oppositis breviuscule petiolatis subcoriaceis late elliptico-oblongis obsolete cordatis apice obtusiusculis 5–8 cm. longis 2–3 cm. latis supra minute puberulo-papillatis mox glabratis nervo medio in longitudinem inconspicue pauciglanduligero subtus pallidioribus dense puberulis; petiolo 0.5 cm. longo minute puberulo; inflorescentiis racemosis lateralibus alternatis; pedunculo 3–5-floro petiolos paulo superante; pedicellis 0.2–0.3 cm. longis; bracteis ovatis scariaceis minimis; calycis laciniis ovato-lanceolatis acuminatis 0.15 cm. longis scariaceis extus minute puberulo-papillatis intus basi squamellam deltoideam laciniatam gerentibus; corollae (flavidulae ?) infundibuliformis extus minute puberulae tubo proprio anguste cy-

lindrico 2.5–3.0 cm. longo basi ca. 0.1 cm. diametro metiente ad apicem staminigero ibique dilatato faucibus conicis 2 cm. longis ostio ca. 1 cm. diametro metiente lobis oblique obovato-reniformibus 1.5 cm. longis valde patentibus; antheris anguste oblongis basi truncate auriculatis 0.5 cm. longis; ovariis oblongo-ovoideis apice abrupte angustatis ca. 0.1 cm. longis dense puberulo-papillatis; stigmate proprio 0.15 cm. longo apiculis sterilibus terminalibus vix manifestis; nectarii glandulis oblongoideis basi connatis ovariis vix aequantibus; folliculis anguste teretibus paulo articulatis 9 cm. longis minute puberulis; seminibus subscaphiformibus 0.5 cm. longis como 1.5 cm. longo aurantiaco.—Brazil: "in montic. Tarurumari fluvii Pacimoni, Feb., 1854." *R. Spruce 3395* (Herbarium Kew., type, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

In *M. anceps*, the predominantly alate stems of *Mandevilla* sect. *Eriadenia* Mgf. attain their greatest development. The species is also noteworthy as being the only known member of the section with a well-developed vegetative indument.

A NEW SCAPOSE DRABA FROM UTAH

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Among the plants collected by the authors in the southwestern United States during the summer of 1930 is a *Draba* which, upon further study, seems to warrant specific recognition. It is described as follows:

Draba subalpina[1] Goodman and Hitchcock, n. sp. Caespitose perennial, the leaves forming rosettes; leaves linear-oblanceolate, entire, obtuse, 6–11 mm. long, midvein apparent, glabrous except for the setose-ciliate simple hairs on the margins; scapes solitary or few, glabrous, 4–6 cm. tall; fruiting inflorescence a lax raceme; pedicels ascending, 4–8 mm. long; siliques ovate to oblong-ovate, flattened, glabrous, 4–7 mm. long, 3–3.5 mm. broad, style 0.7 mm. long; ovary 6–8-ovuled; flowers unknown.—Utah: meadowland, Cedar Breaks, 3,000 m. alt., July 18, 1930, *Goodman & Hitchcock 1622* (Mo. Bot. Gard. Herb., TYPE); Cedar Breaks, July 17, 1922, *M. E. Jones* (Pomona Coll. Herb. No. 117158).

The nearest relative of this species probably is *Draba oreibata* Macbride & Payson, the type of which was collected in central Idaho. *D. subalpina* differs from Macbride and Payson's plant in the larger leaves and in the broader, ovate instead of elliptic siliques. A technical and anatomical difference between the two

[1] **Draba subalpina** Goodman et Hitchcock, sp. nov. Planta perennans caespitosa; foliis 6–11 mm. longis, rosulatis lineari-oblanceolatis, obtusis, integris, utrinque glabris, marginibus setoso-ciliatis, pilis simplicibus; scapis fructiferis 4–6 cm. altis, glabris, solitariis vel paucis; racemis laxis; pedicellis 4–8 mm. longis, ascendentibus; siliquis 4–7 mm. longis, 3–3.5 mm. latis, ovatis vel oblongo-ovatis, compressis, glabris, stylo 0.7 mm. longo; ovario 6–8-ovulato; floribus non visis.—Utah: meadowland, Cedar Breaks, 3,000 m. alt., July 18, 1930, *Goodman & Hitchcock 1622* (Mo. Bot. Gard. Herb., TYPE); Cedar Breaks, July 17, 1922, *M. E. Jones* (Pomona Coll. Herb. No. 117158).

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species is to be found in the outline of the cells of the septum. In *D. oreibata,* as well as in *D. cyclomorpha* and *D. Lemmonii,* these cells are relatively small and in the first mentioned are irregular in outline, more or less straight-sided, and not more than twice so long as broad. In *D. subalpina* the cells of the septum are large, deeply tortuous in outline, and more than three times as long as broad.

Goodman and Hitchcock's No. 1622 was distributed as "*Draba Lemmonii* Wats." under which name it may be found in herbaria.

THE INJURIOUS EFFECTS OF ULTRA-VIOLET AND INFRA-RED RADIATIONS ON PLANTS

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1. Previous Work

Numerous investigations have demonstrated that the radiations emanating from unscreened carbon and quartz-mercury-vapor arcs are decidedly injurious to plant tissue. These effects are quite striking: leaves are glazed and bronzed, the upper epidermis is burned off, stems made brittle, growth stunted. The manifestations of injury have in general been attributed to the ultra-violet wave lengths generated by the arcs; possible effects of the infra-red portion of the spectrum have been almost entirely neglected, not only in the earlier works, but as late as 1929.

Delf, Ritson, and Westbrook ('27) rayed seedlings of *Arachis* and *Trifolium* at 24 inches from a mercury arc and reported injuries which they attributed to ultra-violet. Popp and Brown ('28) rayed cucumbers, turnip, and other species of plants at a distance of 50 cm.—only 20 inches—from an unscreened mercury vapor arc and found that "ultra-violet radiation caused only injury to all the seedlings used." Newell and Arthur ('29) rayed tomato plants at 15 inches with the full spectrum of the mercury vapor arc and wrote of the injurious effects induced by "ultra-violet radiation." It seems incredible that the injury produced in plants when they are irradiated at such short distances from the arc is attributable exclusively to ultra-violet radiation. Intensity measurements made in this laboratory show that at such close proximity to the arc, the infra-red radiation may constitute as much as 90 per cent of the total energy output of the arc. In view of this condition it seems that the infra-red radiation might account for a considerable part of the injury usually referred to the ultra-violet portion of the spec-

trum. The experiments herein reported attempted to determine whether or not this assumption is valid—that is, to what degree the infra-red radiation is responsible for injury to plant tissue.

II. Experimental

The plants used in these experiments were "Bonny Best" tomatoes and red kidney field beans. Plants were grown individually in pots, and at the beginning of irradiation the tomatoes averaged about 7.0 cm. in height, the beans about 21.0 cm. Three experimental groups of both species were arranged as follows:

A. Controls—not rayed.

B. Exposed to a Burdick Quartz Mercury-Vapor arc screened by a quartz cell containing 1.5 cm. of distilled water which provided ultra-violet transmission to 210 mμ but which removed the greater part of the infra-red portion of the spectrum (Luckiesh, '27, pp. 49–50).

C. Exposed to the full spectrum of a Burdick Mercury-Vapor arc transmitting to 210 mμ.

The ultra-violet output of the arc was measured by a Burt ultra-violet photometer; at a distance of 40 cm. from the arc, the ultra-violet intensity per square centimeter of receptive surface was 54 Burt ultra-violet units (grams-calories per square centimeter per minute). The same readings were obtained with the unscreened arc and with the quartz-water cell before the arc; that is, the 1.5-cm. water layer caused no diminution in the intensity of the ultra-violet transmitted. Spectrographs showed also a similar qualitative transmission with and without the quartz-water cell.

Twelve plants of each species were used in each group, with the intention of increasing the numbers later. The results were so conclusive, however, as to exclude errors contributed by individual variation among the plants. The plants were rayed at 15 inches—38 cm.—from the arc for nine days for three minutes daily, during which time significant changes were observed and measurements of increase in height and leaf number were made.

III. Results

1. Tomatoes.—The first signs of injury appeared in the tomatoes 24 hours after the first irradiation, in group C. The epidermal hairs were burned off and a few shiny areas were present on the uppermost leaves of the plants. These signs of injury became intensified with succeeding exposure periods. At the end of nine days the leaves were bronzed and quite brittle, growth had ceased completely, and the plants were obviously dying.

Group B showed definite injury, however to a lesser degree than did group C. In B, the first signs of glazing of leaves appeared after the fourth daily irradiation, a condition comparable to that of C after its first irradiation. At the end of the nine-day period, the total injury in group B consisted of a general glazing of the upper leaves, with a few small bronzed patches scattered here and there; the plants were somewhat stunted in growth but were still growing. They showed considerably less injury than did group C.

Growth measurements of the tomatoes appear in table I:

TABLE I.—TOMATOES

Plant Number	Beginning of irradiation		End of irradiation		Increase in height (cm.)	Increase in number of leaves
	Height in cm.	Number of leaves	Height in cm.	Number of leaves		
Group A: Controls						
1	6.5	6	14.5	8	8.0	2
2	7.0	6	14.0	7	7.0	1
3	7.0	5	15.5	7	8.5	2
4	6.0	5	14.4	7	8.4	2
5	6.5	6	15.1	7	8.6	1
6	8.5	6	17.6	7	7.1	1
7	7.3	7	15.6	8	8.3	1
8	7.7	6	15.0	8	7.3	2
9	6.7	5	14.3	7	7.6	2
10	6.2	5	13.1	6	6.9	1
11	7.1	6	14.6	7	7.5	1
12	6.8	6	15.0	7	8.2	1
				Average	7.78	1.41

Group B: Quartz-water cell

1	7.0	5	12.8	7	5.8	2
2	6.0	5	13.1	7	7.1	2
3	7.0	6	13.0	6	6.0	0
4	6.2	5	13.2	6	7.0	1
5	7.0	6	13.0	8	6.0	2
6	7.5	6	13.6	8	6.1	2
7	6.1	6	12.5	7	6.4	1
8	7.3	7	13.5	7	5.8	0
9	7.1	6	14.0	7	6.9	1
10	6.7	5	12.7	7	6.0	2
11	6.1	5	11.9	6	5.8	1
12	6.4	6	12.7	8	6.3	2
				Average	6.33	1.33

Group C: Open arc

1	7.0	6	11.5	6	4.5	0
2	8.0	6	13.2	7	5.2	1
3	6.5	5	11.5	6	5.0	1
4	7.7	5	13.0	5	5.3	0
5	7.5	6	11.5	6	4.0	0
6	9.0	6	13.5	7	4.5	1
7	7.6	6	11.3	7	3.7	1
8	8.2	6	11.5	6	3.3	0
9	8.4	5	11.9	5	3.5	0
10	7.7	5	11.1	6	3.4	1
11	8.1	6	Dead			
12	6.9	5	10.7	6	3.8	1
				Average	4.20	0.54

2. Beans.—The first signs of injury appeared within 20 hours after the first irradiation period, in group C, as a glazing of the upper leaves. In group B, the leaves showed a comparable condition after the third irradiation period. The plants in group C after the second raying tended to wilt, and the uppermost leaves appeared more or less scorched and dried; the lower leaves soon became bronzed and curled after three or four periods of irradiation. The results in general were quite comparable with those obtaining in the tomatoes: the plants in group C in the beans were near death at the end of nine days, whereas those in B were still growing, although they did show definite signs of injury. The beans seemed more sensitive for the most part to the irradiations than did the tomatoes. The measurements of the beans are presented in table II.

TABLE II.—BEANS

Plant Number	Beginning of irradiation		End of irradiation		Increase in height (cm.)	Increase in number of leaves
	Height in cm.	Number of leaves	Height in cm.	Number of leaves		
Group A: Controls						
1	20.5	1	32.5	6	12.0	5
2	23.5	1	38.0	6	14.5	5
3	24.0	1	38.5	6	14.5	5
4	20.0	1	36.0	6	16.0	5
5	23.0	1	36.5	6	13.5	5
6	21.0	1	35.0	6	14.0	5
7	21.0	1	40.0	7	19.0	6
8	22.5	1	38.5	6	16.5	5
9	24.0	1	Dead			
10	21.5	1	37.5	6	16.0	5
11	18.0	1	29.0	6	11.0	5
12	23.0	1	43.0	7	20.0	6
				Average	15.09	5.18
Group B: Quartz-water cell						
1	23.0	1	32.5	5	9.5	4
2	24.5	1	34.5	5	10.0	4
3	22.5	1	32.0	5	9.5	4
4	21.5	1	30.0	5	7.5	4
5	24.0	1	35.0	5	11.0	4
6	21.0	1	29.5	4	8.5	3
7	24.0	1	Dead			
8	21.0	1	28.5	4	7.5	3
9	24.0	1	35.0	5	11.0	4
10	26.0	1	34.5	4	7.5	3
11	26.0	1	37.0	5	11.0	4
12	20.5	1	33.5	5	13.0	4
				Average	9.63	3.45
Group C: Open arc						
1	20.5	1	24.0	3	3.5	2
2	18.0	1	20.0	4	2.0	3
3	21.0	1	25.0	3	4.0	2
4	24.0	1	28.0	3	4.0	2
5	25.0	1	28.0	3	3.0	2
6	23.0	1	29.0	3	6.0	2
7	22.5	1	27.0	3	4.5	2
8	20.5	1	26.0	3	6.0	2
9	23.5	1	27.0	3	3.5	2
10	24.0	1	29.0	4	5.0	3
11	25.0	1	28.0	3	3.0	2
12	22.0	1	27.5	3	5.5	2
				Average	4.16	2.25

Photographs of the beans and tomatoes are included in plate 3; the plants selected for photographs were some which were nearest the group average in each case.

IV. Summary

1. Radiations from an unscreened quartz mercury vapor arc produce decided injury in the tissues of tomato and bean plants at 15 inches from the arc; in addition, growth rate and leaf production are repressed.

2. The injurious effects at this distance are due in considerable degree to infra-red radiation from the arc.

3. The injurious effects are considerably reduced when a quartz water cell, which screens out infra-red radiation, is interposed between the arc and the plants.

4. It should be emphasized that the present work does not involve problems of stimulation, as previously reported; under the conditions used in this present experimentation, only injurious effects were observed. Stimulatory effects of ultra-violet radiation occur under markedly different methods of treatment, as previously employed.

V. Acknowledgments

The author expresses his gratitude to Dr. Ernest S. Reynolds, under whose general supervision a series of experiments on ultra-violet radiation is being carried out.

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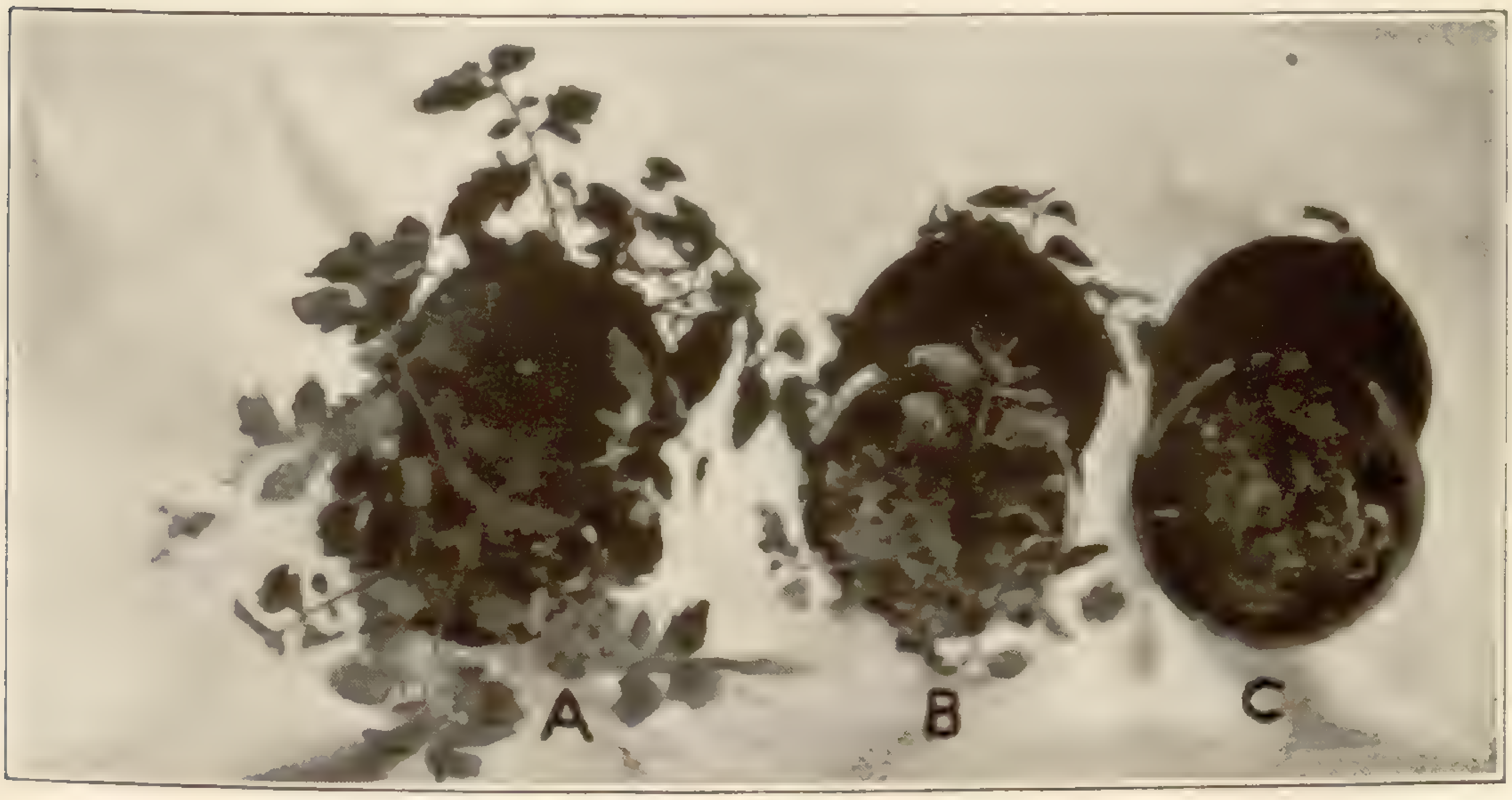
Explanation of Plate

PLATE 3

Fig. 1. Beans.
A—Control.
B—Quartz-water cell.
C—Open arc.
Figs. 2–3. Tomatoes.
A—Control.
B—Quartz-water cell.
C—Open arc.

1

2



3

FULLER—EFFECTS OF ULTRA-VIOLET AND INFRA-RED RADIATIONS

A REVISION OF THE GENUS MENODORA[1]

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History

The genus *Menodora* was founded in 1809 by Humboldt and Bonpland[2] in the 'Plantes Aequinoxiales'; it was based on a Mexican plant, collected on their expedition to Mexico, Central and South America, which was described and illustrated as *Menodora helianthemoides.* The word *Menodora,* derived from the Greek words, μένος, force or courage, and δῶρον, gift, had reference to the force or strength it gave to animals. Since the fruit was unknown to them, Humboldt and Bonpland doubtfully referred the genus to the natural family Jasmineae (now Oleaceae), as established by Jussieu[3] in his 'Genera Plantarum.' In 1825 Kunth[4] elaborated upon the original description of this new genus, making use of the type material. Unfortunately, these specimens had no fruit and thus his description of the fruit as a bilocular, bivalved capsule was taken solely on the faith of Bonpland. He added one significant character, namely, that there were two ovules in each of the two cells of the ovary; he assigned *Menodora* to the Acanthaceae.

The following year Chamisso and Schlechtendal[5] in 'Linnaea' published a new genus, called *Bolivaria,* in honor of Simon Bolivar, the liberator of South America. The plants were collected in the vicinity ot Buenos Aires, Argentina, and described as two species, *B. integrifolia* and *B. trifida.* The striking features of these South American plants were their circumscissile capsules, 5-parted calyx, and 4-seeded cells of the fruit; these characters were considered to be generically distinct from the multifid calyx,

[1] A dissertation presented to the Board of Graduate Studies of Washington University in partial fulfilment of the requirements for the degree of Master of Science.

[2] Humboldt, A. & Bonpland, A. Pl. Aequin. **2**: 98. *pl. 110.* 1809.

[3] Jussieu, A. L. Gen. Pl. 104. 1789.

[4] Kunth, C. S., in HBK. Nov. Gen. et Sp. Pl. **7**: 199. 1825.

[5] Chamisso, A. & Schlechtendal, D., in Linnaea **1**: 268, *pl. 4, fig. 1.* 1826.

Issued April 15, 1932.

bi-ovulate cells of the ovary, and supposedly bivalved capsule of *Menodora,* and thus *Bolivaria* was treated as a new genus, being placed in the Gentianeae.

Bartling[6] recognized both *Menodora* and *Bolivaria* as distinct genera in his 'Ordinales Naturales Plantarum' in 1830, but was in doubt as to their affinities with other genera. He grouped them with other monopetalous genera under the heading, "Genera Dicotyledonea dubia l. incertae sedis."

Dietrich[7] did not approve of *Bolivaria* as a name for a genus, believing that celebrated men in history and politics should not figure in botanical nomenclature. Therefore, he substituted in 1831 in the 'Species Plantarum' the name *Calyptrospermum* for *Bolivaria.* This generic name, however, did not persist, because of the priority of the name *Bolivaria.*

Another species, *Bolivaria decemfida,* was described by Gillies[8] from a South American plant in 1834 in Hooker's 'Journal of Botany.'

In his 'Natural System of Botany' in 1836 Lindley[9] placed *Bolivaria* under the Jasminaceae, regarding *Menodora* as its synonym. In 1838 G. Don,[10] in 'General History of the Dichlamydeous Plants,' recognized both *Bolivaria* and *Menodora,* and assigned them to the Columellieae in coördinate family rank with Oleineae and Jasminaceae. Grisebach[11] further confused the arrangement of *Menodora* and *Bolivaria* in 1839 in his 'Genera et Species Gentianearum' by creating for these genera a separate family, Bolivariaceae. He considered this family as one showing natural affinity with the Gentianeae.

In 1841 Steudel[12] in his 'Nomenclator Botanicus' transferred *Bolivaria trifida* and *B. integrifolia* to the genus *Menodora.*

Endlicher[13] in 'Enchiridion Botanicum' in 1841 recognized *Menodora* and *Bolivaria* as distinct genera. Doubt was expressed as to the number of seeds in each cell of the capsule.

[6] Bartling, F. J. Ord. Nat. Pl. 427–428. 1830.

[7] Linnaeus, C. Sp. Pl. [A. Dietrich], ed. 6. **1**: 227. 1831.

[8] Gillies, in Hook. Jour. Bot. **1**: 284. 1834.

[9] Lindley, J. Nat. Syst. Bot. ed. 2. 309. 1836.

[10] Don, G. Gen. Hist. Dichl. Pl. **4**: 58. 1838.

[11] Grisebach, A. H. R. Gen. et Sp. Gentian. 20. 1839.

[12] Steudel, E. T. Nom. Bot. ed. 2. **2**: 124. 1841.

[13] Endlicher, S. Ench. Bot. 285. 1841.

In 1842 the fifth species, an African one, and the first to be described from the Old World, *Menodora africana*, was published by Sir Wm. J. Hooker[14] in Hooker's 'Icones Plantarum,' and supplemented with a good illustration.

In the 'Prodromus' in 1844 de Candolle[15] recognized *Menodora* and *Bolivaria* as distinct genera. Two new species were included, *Menodora heterophylla* from Texas and *Bolivaria Mexicana* from Mexico. These two genera were distinguished by the number of seeds in each cell of the capsule, the circumscissile dehiscence of the capsule, and the five to ten calyx-lobes of *Bolivaria*, as contrasted with the supposedly indehiscent capsule, and eleven to fourteen calyx-lobes of *Menodora*.

Between 1846 and 1852 three new species were added to *Bolivaria*, *B. robusta* from Argentina, *B. chlorargantha* from Bolivia, and *B. Grisebachii* from Texas.

In 1852 Asa Gray[16] in the 'American Journal of Science and Arts' showed that *Bolivaria* and *Menodora* were congeneric, and referred all the hitherto-published species of the two groups to *Menodora*, and in addition described four new species, bringing the total known species to thirteen. He recognized three sections in the genus, *Bolivaria*, *Menodora*, and *Menodoropsis*. This treatment of the genus definitely settled the question concerning the retention of *Bolivaria* as a valid genus. In 1878, in his 'Synoptical Flora of North America,' he[17] described all the North American species.

Approximately twenty species and a limited number of varieties have been recorded for the genus *Menodora*, but no comprehensive treatment of the group has been elaborated since de Candolle's 'Prodromus' in 1844.

The writer takes this opportunity to express his appreciation and gratitude to the several persons who have made this study possible. Thanks are due to Dr. George T. Moore, Director of the Missouri Botanical Garden, for the privilege of using the excellent library and herbarium. Especial thanks are due to

[14] Hooker, W. J., in Hook. Ic. Pl. *pl. 586*. 1842.
[15] A. de Candolle, in DC. Prodr. **8**: 315–316. 1844.
[16] A. Gray, in Am. Jour. Sci. II. **14**: 41. 1852.
[17] A. Gray, in Syn. Fl. N. Am. **2**[1]: 78. 1878.

Dr. J. M. Greenman, Curator of the Herbarium of the Missouri Botanical Garden, under whose guidance this revision has been carried on, who at all times lent such helpful aid and criticism. Sincere gratitude is due Dr. Mildred E. Mathias, formerly Research Assistant at the Missouri Botanical Garden, who so kindly gave advice and suggestions. Appreciation is also due the curators of all the herbaria from which material has been borrowed for this study.

General Morphology

The genus *Menodora* presents an interesting habital deviation from the other genera in the Oleaceae, for whereas this family comprises mostly shrubs, trees, or lianas, the genus *Menodora* consists of low suffruticose plants.

Root.—The root system consists of a simple, stout, woody, perennial tap-root, which varies considerably in length. In a few instances in which the plants have been growing on rocky, steep slopes, specimens show the root extending in a horizontal direction. The perennial root develops a thick woody crown, which branches freely, sending out numerous ligneous axes from which the stems of the season develop.

Stem.—The stems present a wide range of conditions. In height they vary from 0.3 to 0.4 dm., as in *M. helianthemoides* var. *Engelmannii* and var. *humilis*, to 11 dm., as in *M. robusta*. The shoots of the coming season develop from the primary ligneous axes. These new stems are subherbaceous in most of the species, as is well shown in *M. heterophylla*, *M. scabra*, and *M. integrifolia* var. *trifida*. In a few cases, however, as in *M. robusta*, *M. spinescens*, *M. juncea*, and others, the suffruticose tendency is more evident.

The stems during the period of growth are simple and elongated, as, for example, in *M. heterophylla* and *M. scabra*, or are markedly branched, as is shown in *M. juncea*, *M. intricata*, *M. decemfida*, and others. The branches are mostly opposite below, but become approximate and then alternate towards the reproductive shoots.

There are two main types of stem habit. In one, which includes the majority of the species, the stems are erect and strict, as in *M. juncea*, *M. scoparia*, *M. robusta*, and *M. longiflora*. In the

other, the stems are more or less decumbent and diffusely spreading, as, for example, in *M. integrifolia* var. *trifida*, *M. helianthemoides* var. *Engelmannii*, *M. helianthemoides* var. *parviflora*, and others. In *M. intricata* they are intricate.

The stems, due to the decurrent petioles, are usually more or less angled. This condition is especially well exemplified in *M. decemfida* var. *longifolia*, *M. intricata*, and *M. scabra*. *Menodora spinescens* and *M. robusta* have terete stems. In *M. intricata* the stems are very much ribbed on account of the decurrent petiole being strongly ridged in the middle and along the margins.

In most of the species the stems are slender, but in *M. robusta* and *M. spinescens* they are stout.

The stems are generally unarmed, but in *M. robusta* a spinescent condition is approximated by the tips of the branches becoming gradually conical. The pseudo-spinosity in *M. robusta* develops into a true spinose state in *M. spinescens* and its variety *mohavensis*.

Leaves.—The leaves are generally opposite, but vary to approximate or alternate as they approach the inflorescence. They may be fascicled, as on some of the flowering shoots of *M. spinescens*. They are mostly sessile, although they may be narrowed at the base into a slight petiole. They are practically always subcoriaceous, and subtended below by a single prominent nerve.

The leaves vary in shape from narrowly linear to suborbicular. They are entire in the majority of the species, but they may be lobed or pinnatifid. In *M. pinnatisecta* they are linear to deeply pinnatisect. This condition becomes even more pronounced in *M. africana*, in which the leaf segments are narrowly linear, less than 0.5 mm. broad, and appear heath-like. The leaves vary in length from 2 to 55 mm., and in breadth from 1 to 30 mm.

A number of species exhibit an interesting reduction series in the foliage. In most species the leaves are foliose throughout. In *M. scabra*, for example, all of the leaves are well developed, and the internodes are short. Beginning with a species, such as *M. scoparia*, the leaves at the base of the branches are foliose and functional, but towards the upper parts of the shoots they show a tendency to become reduced to a more or less rudimentary state, while the internodes become elongated. From such a con-

dition as this it is relatively easy to proceed to a species, such as *M. intricata*, in which all of the leaves have become reduced to a rudimentary state, to *M. juncea* where they have degenerated to mere vestiges, and to *M. robusta*, where, with the exception of a few small leaves on the upper shoots, they are practically obsolete.

Pubescence.—The usual type of pubescence consists of short simple hairs. Frequently the pubescence on the stems is confined to the margins of the decurrent petioles. It may be very sparse, as in *M. heterophylla*, or more pronounced, as in *M. Coulteri*, *M. helianthemoides*, *M. scabra*, and hairy forms of *M. longiflora*. The last species varies from entirely glabrous to densely pubescent. Most of the pubescent species are more or less scabrous. *Menodora scabra* and its varieties, *M. Coulteri*, *M. intricata* var. *Purpusii*, *M. longiflora*, and *M. helianthemoides* var. *magniflora* are examples of species in which the scabrous hairs are scattered and diffusely spreading, whereas *M. helianthemoides* var. *Engelmannii* and *M. spinescens* possess a very short closely appressed type of hirtellous pubescence. *Menodora helianthemoides* and its variety *humilis*, and some extremely pubescent forms of *M. longiflora* are striking instances of species possessing relatively long, spreading hairs of a hirsute-pilose nature. Some of the species of *Menodora*, such as *M. decemfida*, *M. intricata*, *M. juncea*, *M. integrifolia*, and *M. pinnatisecta*, are glabrous throughout.

Inflorescence.—The inflorescence fundamentally is cymose. In all cases it probably has been derived from a dichasium. In *M. scabra* and *M. longiflora* the cyme is many-flowered and subcorymbose, whereas in *M. scoparia* it is more or less paniculate. In *M. pinnatisecta* it is dichasial below, but shows a tendency to become monochasial above. The flowers appear solitary and remote, and terminal or axillary in the upper leafy branches in those species which have a reduced cyme. Such a type occurs in the decumbent and diffusely spreading species, as *M. heterophylla*, *M. Coulteri*, *M. pulchella*, *M. integrifolia* var. *trifida*, and *M. helianthemoides* and its varieties. In *M. spinescens* and *M. robusta* the flowers are solitary and almost sessile at the ends of short lateral branches. The flowers are devoid of either bracts or bracteoles. The behavior of the pedicel in fruit provides an important diagnostic character. In the majority of the decum-

bent and diffusely spreading species, such as *M. heterophylla*, *M. pulchella*, *M. Coulteri*, *M. helianthemoides* with its varieties, and others, it is recurved in fruit, whereas in those species erect and more or less strict in habit, the pedicel is erect in fruit. An intermediate condition is found in *M. integrifolia* var. *trifida*, which is

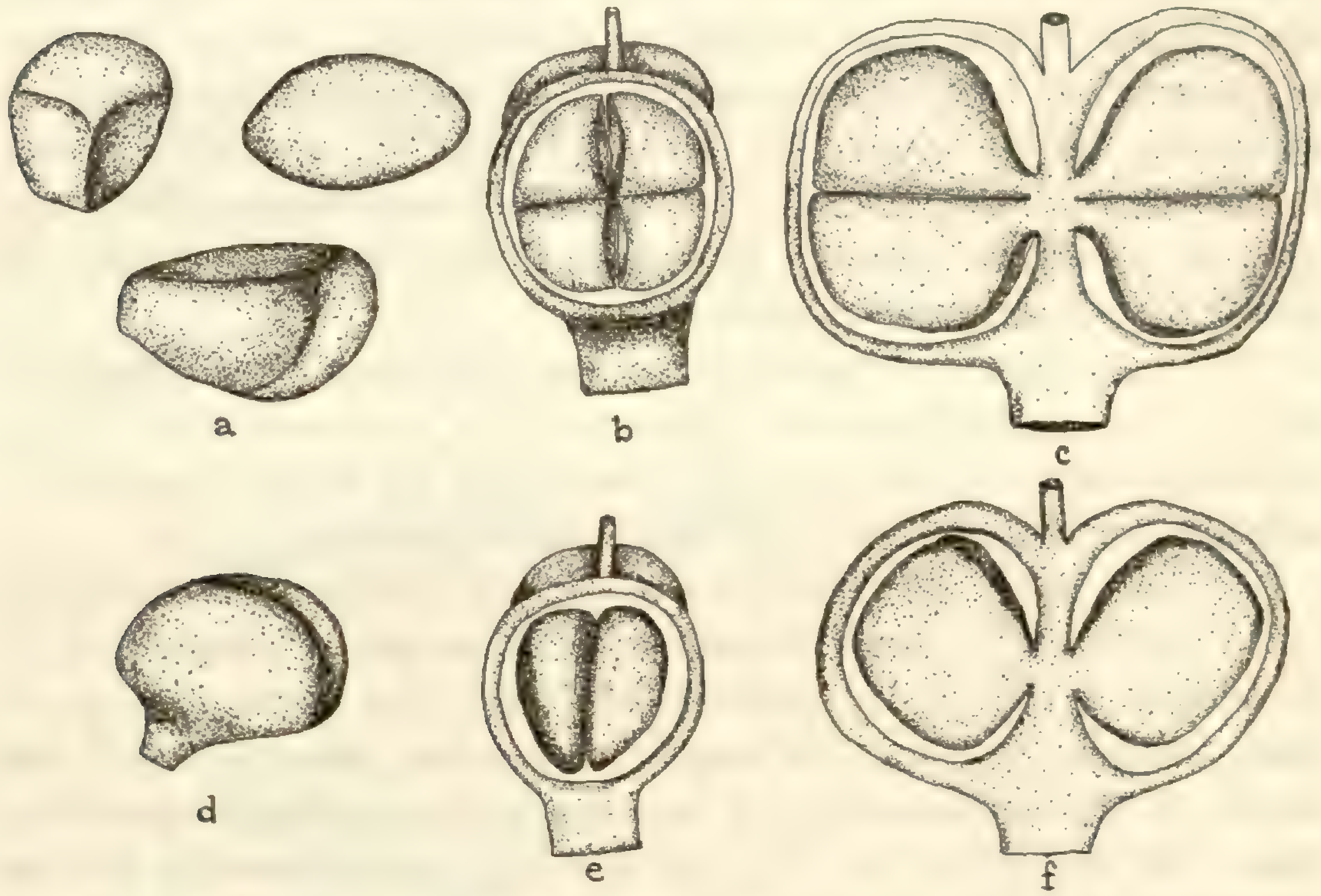

Fig. 1. Drawings showing the position and number of ovules in the two subgenera, *Eumenodora* and *Duogyne.*

a. Ovules of the subgenus *Eumenodora:* ovule seen from below on the inner angle; outer, convex surface of ovule; and inner, flat contact-surface seen from the inner angle. × 21.

b. Dorsal view of the ovary with portion of pericarp removed, showing position of ovules in *Eumenodora.* × 18.

c. Lateral view of the ovary with portion of pericarp removed, showing position of ovules in *Eumenodora.* × 21.

d. Ovule of the subgenus *Duogyne,* showing flat, inner surface. × 21.

e. Dorsal view of the ovary with portion of pericarp removed, showing position of ovules in *Duogyne.* × 18.

f. Lateral view of the ovary with portion of pericarp removed, showing position of ovules in *Duogyne.* × 21.

decumbent and diffusely spreading, but has erect pedicels in fruit. The pedicels are usually short in the early stages, but become elongated in fruit.

Calyx.—The calyx varies in length from 0.4 cm. or less, as in

M. helianthemoides var. *Engelmannii*, to nearly 2.5 cm., as in *M. longiflora*. In most of the species it is approximately equal in length to the corolla-tube, but in *M. longiflora* and *M. robusta* it is usually from one-third to one-fourth the length of the corolla-tube. Although the calyx-lobes vary in number from five to fifteen, the number is relatively constant for individual species. For example, *M. helianthemoides* has from ten to thirteen calyx-lobes, whereas *M. integrifolia* has only five or six. The calyx-lobes are variable in length, mostly linear, but in *M. robusta* they are deltoid, and in *M. africana* and *M. Coulteri* they are setaceous. They are usually entire; a notable exception occurs in *M. africana* in which the lobes are frequently cleft.

The calyx-tube is turbinate or campanulate, and generally short. It is markedly nerved, the number of nerves corresponding to the number of lobes present. The tube of the calyx is persistent and becomes slightly enlarged as the fruit matures.

Corolla.—With the exception of a few species the corolla is fairly constant in shape throughout the genus. Generally, it is subrotate or shortly infundibuliform, the tube varying in these cases from 3 to 7 mm. in length, and being generally half the length of the corolla-lobes, or in some instances barely equalling them (fig. 2d). Two or three species are exceptional in having relatively long tubes. *Menodora spinescens* var. *mohavensis* has an infundibuliform corolla-tube 10 mm. in length; *M. robusta* has an infundibuliform tube about 12 mm. long, whereas *M. longiflora* has the greatest extreme, with a hypercrateriform tube varying in length from 25 to 53 mm. (fig. 2c). In all species save one, *M. longiflora*, in which the tube is entirely glabrous, the corolla-tube is bearded within at the orifice, the slender hairs occurring mostly around the area where the filaments are inserted upon the throat.

The corolla-lobes are usually five in number, but six occasionally occur. In shape they vary from narrowly oblong to broadly obovate or ovate, as in *M. longiflora*. They are obtuse or acute, and frequently slightly or distinctly mucronate, imbricated in aestivation, and usually spreading at anthesis. They are generally glabrous, but in *M. scabra*, *M. helianthemoides*, and others they are sparsely scabrous-puberulent without.

The corolla is usually golden-yellow or white, but in some

species, as *M. heterophylla* and *M. spinescens* var. *mohavensis*, it is tinged brownish or dull purplish-red without. Engelmann noticed that the short-tubed, inodorous flowers, as those of *M. heterophylla* and *M. scabra*, are open during the day, whereas the

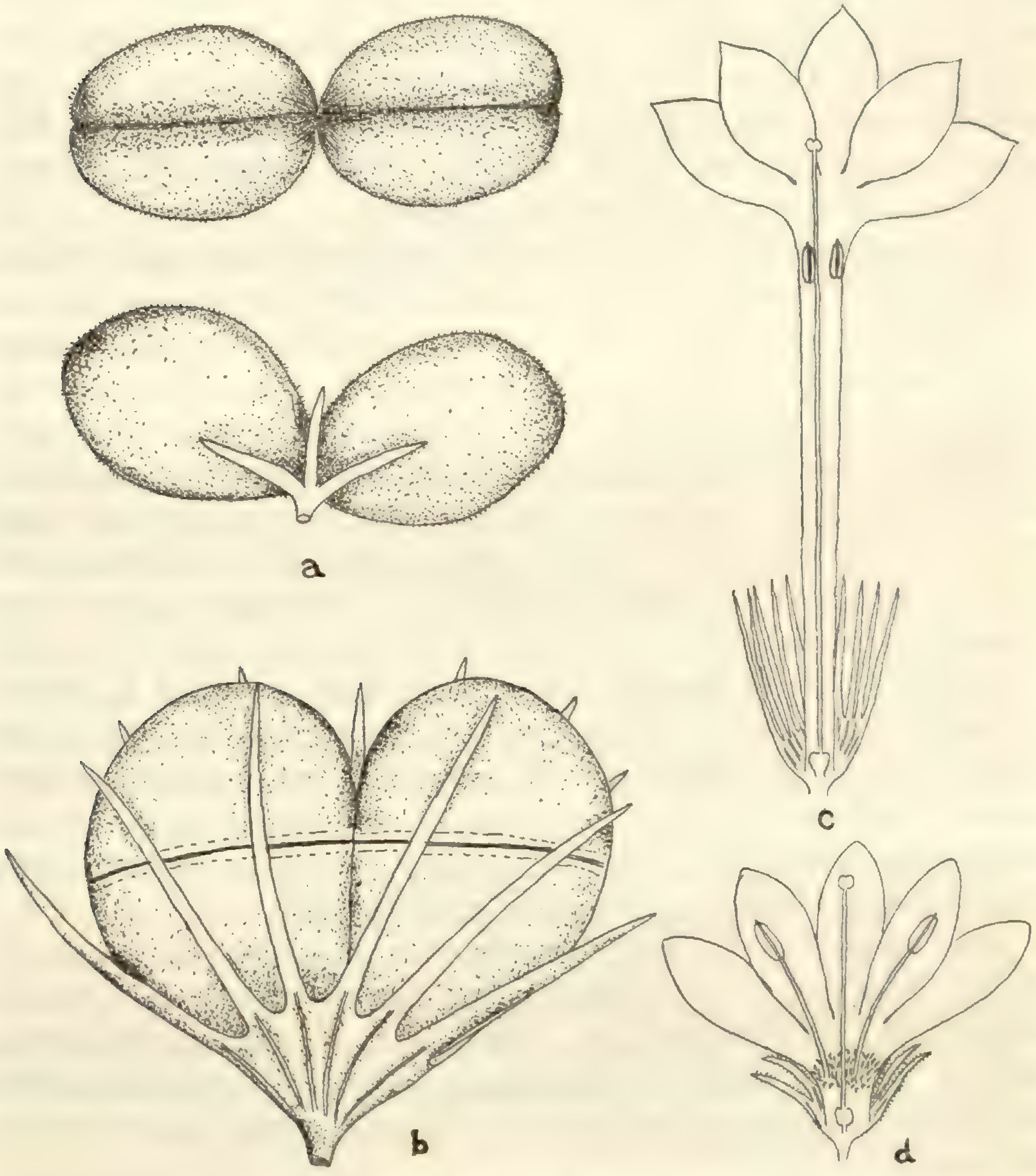

Fig. 2.

a. Fruit of the subgenus *Duogyne;* upper figure, capsule from above, showing suture along the vertical plane; lower figure, lateral surface view of capsule, showing divaricate cocci. × 3.

b. Fruit of the subgenus *Eumenodora*, lateral surface view. × 4.

c. Flower of *M. longiflora*, the corolla and calyx opened. × 1.

d. Flower of *M. Coulteri*, the corolla and calyx opened. × 1.

long-tubed, sweet-scented flowers, as of *M. longiflora,* are open at night.

Stamens.—The stamens are two in number, thus according with all other genera in the family. They are equal in length, and are inserted on the corolla-tube near the orifice. When the corolla-tube is short, the stamens are exserted (fig. 2d). In *M. longiflora,* however, the stamens are included near the orifice (fig. 2c). In this last species the anthers have such short filaments as to appear almost sessile, whereas in the majority of the species the anthers are borne on relatively elongated filaments.

Although the filaments are inserted near the orifice of the corolla, their central vascular strand, as well as the surrounding parenchymatous tissue, can be traced externally along the corolla-tube from the point of insertion of the filaments to the base. Thus, since the filaments are in reality adnate to the tube for some distance, it seems desirable in taking length-measurements of the entire stamen or filament to include that part of the staminal tissue which is adnate to the corolla-tube. The filaments are usually glabrous and erect, but those in *Menodora robusta* are densely pubescent.

The anthers are usually oblong and quite constant in shape throughout the genus. They are about 2 mm. long in most of the species, but in *M. robusta* and *M. spinescens* var. *mohavensis* they attain a length of 4 mm. They are introrse, dehiscing longitudinally along lateral slits, attached dorsally to the filament and basifixed, though appearing versatile superficially.

The connective is usually prolonged more or less at the apex. In *M. longiflora* it is triangular and very conspicuous. In *M. integrifolia, M. decemfida, M. scabra,* and *M. scoparia* it is prolonged into a rather conspicuous cylindrical protuberance. *Menodora spinescens* is an exception in not having the connective prolonged.

The pollen has been studied in all the species and varieties of *Menodora,* as well as in seventeen other genera in the family, including all the tribes and subsections in the Oleaceae, and in all instances the exine has been observed to be more or less reticulate, either regularly or irregularly (pl. 4, figs. 1–4). The pollen grain of species of *Menodora* has three germinal apertures. The size of

the grain is remarkably constant for each species, and in most species it averages from 60 to 90 μ in diameter. The smallest grains are found in *M. spinescens* (pl. 4, fig. 1), ranging from (33.75); 39.9 to 50 μ[18] in diameter, while the largest occur in *M. longiflora*, ranging in diameter from (112.55); 125 to 143.75; (162.50) μ. *Menodora robusta* (pl. 4, fig. 3) has larger reticulations than any of the other species, while *M. africana* (pl. 4, fig. 2) and *M. intricata* have the smallest type of reticulation.

The technique used in the present study of the pollen grains closely approximates that outlined by Wodehouse.[19] Herbarium material was used throughout. First the flower was boiled until sufficiently softened, after which initial process it could be preserved in 70 per cent alcohol or transferred directly to the mounting medium. When ready for mounting the specimen was transferred to a slide, where by aid of needles under the dissecting binoculars the pollen was removed from the anther. A drop of water was then added and the cover-glass was placed on the slide. A dilute solution of Amann's lactophenol mounting medium was finally placed around all sides of the cover glass and allowed to diffuse gradually towards the center.[20] By means of this stain the characters of the exine markings were brought out more clearly. The nature of the reticulation and the variation in size of the pollen grain served in part as checks or confirmatory evidence for the affinities existing between the various species.

Pistil.—The pistil in the genus *Menodora* is typically bicarpellary and accords in structure with other members of the Oleaceae. The style is simple, filiform, elongated and usually about as long as the corolla-tube. One teratological case was observed in which two free styles were found in a flower of *M. spinescens.* The stigma is usually broadly capitate and more or less emarginate. In *M. africana, M. spinescens,* and a few other species, it is small and more or less obtuse.

The bilocular ovary is fleshy and bilobed. The placentation is axillary. The ovules are two to four in number, collateral, and

[18] The parentheses marks indicate the extreme in size.

[19] Wodehouse, R. P. The phylogenetic value of pollen-grain characters. Ann. Bot. **42**: 896–898. 1928.

[20] Linder, D. H. An ideal mounting medium for mycologists. Science **70**: 430. 1929.

attached about half way up the placentae. The integument is very thick and fleshy and the surface becomes conspicuously reticulated as the ovule matures. The subgenera *Eumenodora* and *Duogyne* present an interesting contrast in regard to the number and arrangement of the ovules. All the species of *Eumenodora* have in each cell four ovules arranged collaterally in pairs, superimposed and horizontal in position (fig. 1 a–c). The funicles are very proximate. The ovules are compressed in two planes; because of this pressure from two sides, they are always trigonal, being flattened on the two inner faces of contact and convex on the outer third free surface. This trigonal shape persists from the development of the ovule to that of the seed. In contrast to this condition it was found that in the species belonging to the subgenus *Duogyne* there are only two ovules in each cell (fig. 1 d–f). These ovules are slightly ascending, with a dorsal raphe and a micropyle pointing below. They are likewise compressed, but because of the fact that the pressure exists in one plane only, their shape is plano-convex rather than trigonal, the inner face of contact being flattened, while the outer free surface is convex. This shape likewise persists in the contour of the mature seed.

Some confusion has arisen in the past concerning the number of ovules in each cell. One reason for this confusion is that the ovules stick together closely, and, unless a careful dissection is made, could readily be taken as two instead of four, as is the case of those species included in the subgenus *Eumenodora*. An instance of such an oversight is to be found in Bentham's original description and illustration of *Bolivaria robusta*,[21] in which the number of ovules is described as follows: "ovula in quoque loculo 2, loculum implentia . . ." Philippi[22] in 1864 described a new species, *M. linoides*, as possessing two ovules in each cell, and the description reads "loculis biovulatis," but no authentic material of this species has been examined.

Fruit.—The fruit of the genus *Menodora* at once distinguishes it from all other Oleaceous genera. It is a bilocular capsule, each loculus being referred to as a coccus. In those species belonging

[21] Bentham, G., in Hook. Lond. Jour. Bot. 5: 190. *pl. 5.* 1846.

[22] Philippi, R. A., in Linnaea 33: 174. 1864.

to the subgenus *Eumenodora* the capsule dehisces circumscissilely, namely, transversely to the vertical axis (fig. 2b). This line along which the dehiscence occurs does not become conspicuous, however, until the fruit nears maturity. At maturity each of the cocci dehisces by this horizontal suture, and the upper half becomes free. The number of mature seeds in the species in this subgenus is usually four. An exception to this may be found in *M. africana*, in which some of the seeds fail to mature. The placentae are not evident in the mature capsule of this subgenus. After fertilization the ovules greatly enlarge, extending the pericarp, and in so maturing become displaced from their original position. Thus, the mature seeds, having become displaced during development, now appear to arise from the lower inner angle at the base of each coccus. Due to the growth of the gynoecium upwards after fertilization, however, the seeds are more or less ascending rather than horizontal.

In the subgenus *Duogyne* the fruit is not a circumscissilely dehiscent capsule. In contrast, a median longitudinal suture or stricture appears in the vertical plane (fig. 2a). However, no indications of dehiscence along this suture are evident. Moreover, each valve of the capsule is two- rather than four-seeded.

In those species included in the subgenus *Eumenodora* the cocci are subglobose, smooth, glabrous, and nearly proximate (fig. 2b), whereas in the subgenus *Duogyne* the cocci are ovoid or obovoid, minutely pubescent, and conspicuously divaricate, appearing almost as separate capsules (fig. 2a).

The seeds consist of two coats, an inner, brown, smooth, subcoriaceous one, and an outer, brown, thick, spongy, variously reticulated one. Some species, as *M. heterophylla*, *M. longiflora*, *M. scoparia*, and others, have a coarse, deep-grooved reticulation, whereas others, such as *M. scabra* and *M. spinescens*, possess a very minute reticulation which appears almost smooth to the naked eye. In some species the reticulation is quite regular, in others exceedingly irregular.

In those species comprising the subgenus *Eumenodora* the seeds are, as in the case of the ovules, trigonal. In the subgenus *Duogyne*, on the other hand, the seeds are plano-convex, as were the ovules.

Embryo.—The embryo in all cases is straight, large, and completely fills the seed. The cotyledons are flat, the radicle is inferior, and endosperm is completely lacking.

Geographical Distribution

The genus *Menodora* presents a very interesting problem in plant distribution. Of the seventeen species and thirteen varieties recognized in this paper, nine species and eleven varieties occur in North America, six species and one variety in South America, and two species and one variety are found in Africa,

Fig. 3. Map showing general distribution of *Menodora*.
Map reproduced by permission of American Map Co.

one of the species, *M. heterophylla*, being found in North America and having its variety in Africa. There are, accordingly, three distinct areas of distribution: (1) southwestern United States and Mexico, (2) central and southern South America, and (3) South Africa. Despite this extensive tricontinental distribution, it will

be noted that the genus inhabits a definite belt ranging between the extremes of 18° to 45° North and South latitudes (fig. 3). Furthermore, in those three areas of distribution a similar set of environmental conditions exists—similar rainfall and temperature extremes as well as topographic conditions. It may be generally stated that the genus *Menodora* is limited to arid or semi-arid rocky plateaus or stony slopes in mountainous regions. It should be stated that the deserts and semi-deserts of the southwestern United States, the arid Mexican, southern and central Bolivian, the central and eastern Argentine plateaus, the arid central Chilean region, the South African Karroo tableland, and the region north of it, are all topographically and environmentally similar, and all have a similar characteristic xerophytic type of vegetation.[23] The various modes of external morphological response of species of *Menodora* to these xerophytic conditions are extremely interesting. The leaves have become variously reduced, subcoriaceous with incurved margins, and the stomata occur below the surface plane of the epidermis; in *M. robusta* the tips of the branches have become conical, producing a spiny appearance, the leaves on the main branches are greatly reduced, and most of the chlorophyll production has been taken over by the stout, fleshy, green stems. True spines may develop in *M. spinescens* and its variety *mohavensis*.

The restricted range of most of the species is another interesting phase in the matter of the present geographical distribution of the genus. In respect to the number of forms, the genus is best represented in Mexico, where four species and seven varieties are endemic, in addition to four other species and varieties extending into Mexico from the United States (fig. 4). The greatest number of individuals, however, has been collected in the southwestern United States, particularly in New Mexico, Arizona, and Texas. Many of the species and varieties on the Mexican plateau have very circumscribed areas of distribution (fig. 4). For example, *M. helianthemoides* is known only from the state of Puebla; *M. helianthemoides* var. *parviflora* from the states of Puebla and Hidalgo; *M. helianthemoides* var. *humilis* from San Luis Potosi;

[23] Schimper, A. F. W., transl. by R. W. Fischer. Plant geography, pp. 604–649. Oxford, 1903.

Fig. 4. Map of the geographical distribution of *Menodora* in western United States and Mexico.

- *M. helianthemoides.*
- *M. helianthemoides* var. *humilis.*
- *M. helianthemoides* var. *magniflora.*
- *M. helianthemoides* var. *Engelmannii.*
- *M. helianthemoides* var. *parviflora.*
- *M. Coulteri.*
- *M. Coulteri* var. *minima.*
- *M. mexicana.*
- *M. heterophylla.*
- *M. scabra.*
- *M. scabra* var. *laevis.*
- *M. scabra* var. *ramosissima.*
- *M. scabra* var. *longituba.*
- *M. decemfida* var. *longifolia.*
- *M. longiflora.*
- *M. scoparia.*
- *M. intricata.*
- *M. intricata* var. *Purpusii.*
- *M. spinescens.*
- *M. spinescens* var. *mohavensis.*

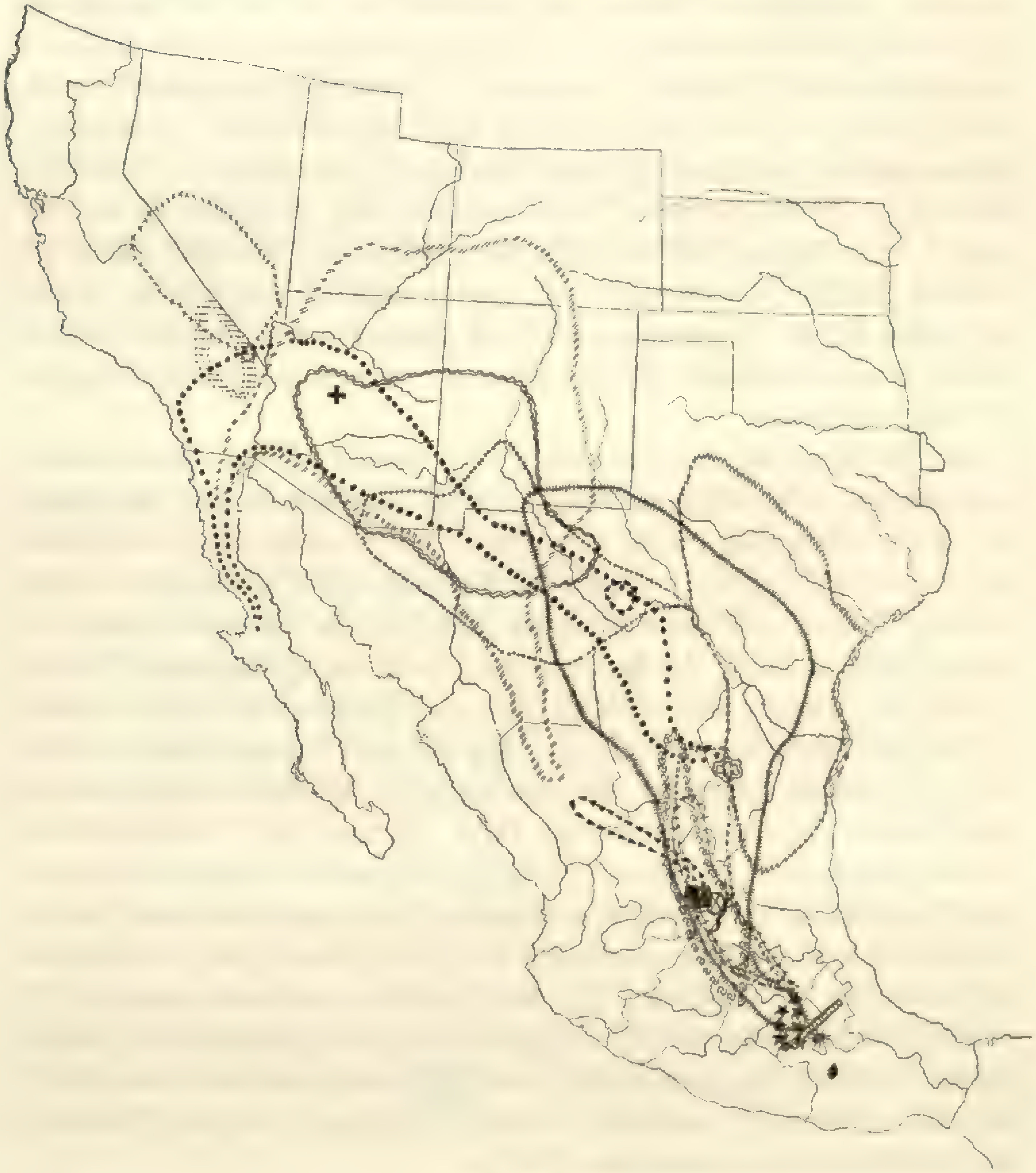

Fig. 4.

M. intricata from Minas de San Rafael in the west-central portion of the state of San Luis Potosi, while *M. intricata* var. *Purpusii* has been found only in the mountains near Tehuacan in southern Puebla. *Menodora Coulteri* var. *minima* has the widest range of any of the Mexican endemics, extending from the state of Coahuila to south-central Mexico. Likewise, in South America and South Africa most of the species are of local distribution. However, this apparent localization may be due to the paucity of collections from these regions. For instance, *M. pulchella* is known only from southern Bolivia, *M. decemfida* from the arid region of Central Chile, *M. robusta* from southeastern Argentina, while in South Africa *M. africana* and *M. juncea* occur locally on the Karroo tablelands and on the plateaus of the mountainous area to the northeast.

On the other hand, a number of species are of more widespread occurrence. *Menodora scabra* of North America covers the greatest area, extending from southern and Lower California and south-central Colorado south to the state of Durango in west-central Mexico. Of those species found in the United States, *M. heterophylla* extends the farthest eastward, occurring near Corpus Christi in Texas; this species covers southwestern and central Texas and extends southward to the state of Tamaulipas in Mexico. *Menodora longiflora* also has quite an extended range, being distributed from southeastern New Mexico and southwestern Texas, south to the state of Puebla. *Menodora scoparia* follows a narrow plateau belt in the mountains from southern and Lower California and Arizona southeast to the southern part of the state of Coahuila in Mexico. Of the South American species, *M. integrifolia* and its variety *trifida* cover fairly large areas, being found between the parallels 20° and 35° South latitude in southern Bolivia, Paraguay, southern Brazil, Uruguay, and northeastern and north central Argentina (fig. 5).

The genus *Menodora* at the present time occupies three remote areas of distribution, but in all probability had a more continuous geographical range at least before the end of the Cretaceous period. The most logical source of evidence explaining this present interrupted distribution lies in the postulation of a land-bridge once connecting South America and Africa, which geologists have

Fig. 5. Map of the geographical distribution of *Menodora* in South America.

C *M. pulchella.*
∝ *M. integrifolia.*
β *M. integrifolia* var. *trifida.*
= *M. Hassleriana.*
M. pinnatisecta.
S *M. decemfida.*
M. robusta.

named Gondwana. It is thought that at one time there existed but one continent; there is evidence, both paleontological and paleontoclimatical, that at the beginning of the Paleozoic era such was the case. This hypothesis is based on the relatively recent development of the large oceans, and upon the world-wide past distribution of various plants and animals.[24] More particularly the postulation of a land connection between South America and Africa has been set forth to explain the past and present distribution of flora and fauna. In connection with this there are numerous bits of evidence that lend support to the idea of the previous existence of Gondwana. The first relates mainly to widespread deposits of the Gangamopteris flora of Permian age. "This flora occurs throughout the southern hemisphere, and paleobotanists hold that it could have been so widely distributed only across a continuous land. . . Without this continent, on the other hand, paleontologists cannot explain the known distribution of Permian land life, and further, its presence is equally necessary for the interpretation of the peculiar distribution of marine fauna beginning certainly with the Devonian and ending in the Jurassic."[25] Another piece of evidence pointing to the previous existence of a land connection between South America and Africa is the zone known as the "Mid-Atlantic Swell." Daly says: "The zone where the New and Old Worlds were torn apart is plausibly regarded as the so-called Mid-Atlantic Swell, which is a long and broad 'ridge' on the ocean's floor; its height averages about one mile, or sixteen hundred meters. . . The ridge or swell is in the middle of the Atlantic basin, about half-way between Brazil and Africa. . . The Ascension Island and other volcanoes on the swell have erupted fragments of typical continental rocks to the surface. The swell may, therefore, conceivably represent a long strip of the original continent, a strip left behind when that continent was torn into fragments, which slid away, respectively, to westward and to eastward. Other masses, like the rugged pile of the Azores, may also represent sunken pieces of the original continent."[26] Additional evidence that such a

[24] Daly, R. A. Our mobile earth. pp. 311–315. 1926.
[25] Schuchert, C. C. Text-book of geology. Part II, pp. 432–433. *fig. 145.* ed. 2. 1924.
[26] Daly, R. A. *loc. cit.* pp. 279–280. 1926.

continent may have existed is to be found in the striking correspondence between the geology of South Africa and that of Argentina. Daly says in reference to this: "A dozen peculiar features of the one region are repeated in the other. . . . In both of these mutually distant lands, thick deposits were made by glaciers, away back in the Paleozoic era, many tens of millions of years before the familiar last Glacial period began in North America. These ancient glacial deposits of the southern hemisphere have been hardened into tough rock."[27] Thus, various bits of evidence lend support to the hypothesis of this lost continent.

The postulation of this land-bridge may explain the range of the genus in three continents, and especially in South America and South Africa. This hypothetical lost continent might also account for the presence of *M. heterophylla* in North America and its variety in South Africa. However, according to geological records, this hypothetical land connection between South America and Africa was obliterated by upper Cretaceous time.[28] Consequently it would seem that the genus *Menodora*, in order to have attained this widespread distribution, and particularly in having a species and a closely related variety at present occurring on two distant continents, must necessarily have been in existence at least before the end of the Cretaceous period. Such a situation would seem highly probable, especially since, according to paleontological records, angiosperms had attained a world-wide distribution by the earlier half of the Cretaceous.[29] This would presuppose the supposition that they were existing in the Jurassic or even in the Triassic period. Although there are no known Cretaceous records of fossil Oleaceae that are worthy of credence, Berry[30] points out that "It is obvious from the early Eocene occurrence of leaves of *Fraxinus* associated with characteristic fruits, that the family must have been evolved before the close of the Upper Cretaceous but none of the genera have any well-marked or abundant known representation until Tertiary times."

[27] *loc. cit.* pp. 285–286.

[28] Schuchert, C. C. Text-book of geology. Part II, pp. 510, 547–548, 610, ed. 2. 1924.

[29] *loc. cit.* pp. 550–561.

[30] Berry, E. W., in Am. Phil. Soc. Proc. **53**: 243. 1914.

No species of the genus *Menodora* have been found so far in the fossil state. This may be accounted for by the fact that the plants grow in arid regions, especially on high plateaus; they apparently come and go without being preserved, because such conditions seem to be unfavorable for preservation.

From the evidence just presented, it seems not unlikely that the genus *Menodora* was at one time, probably not later than the end of the Cretaceous period, distributed at least from South America to Africa, this range being made possible by the existence of the hypothetical land-bridge, Gondwana. The existence of this lost continent might explain the present distribution of *M. heterophylla* in North America and its variety in South Africa, as well as the extended distribution over the three continents in which the genus is now found.

A somewhat parallel example of similar discontinuous distribution is cited by Hill[31] in his discussion of the genus *Vernonia*.

Systematic position

The genus *Menodora* belongs to the tribe Jasmineae of the Oleaceae. A similarity in floral structure exists between the genera *Menodora*, *Jasminum*, and *Nyctanthes*, as shown by the variable number of calyx- and corolla-lobes, the imbricated aestivation, the prolonged corolla-tube, and the short, included anthers. A further evidence of this affinity is to be seen in the large reticulations on the exine of the pollen-grain. The species of *Menodora* best illustrating these relationships are *M. longiflora* and *M. robusta*.

Phylogeny

There are two chief lines of development manifest in the genus *Menodora*, which are emphasized by the subgeneric categories, namely, *Eumenodora* and *Duogyne*. The characteristics of the first are (1) the four-ovulate cells of the ovary with trigonal-shaped ovules, (2) the circumscissile dehiscent nature of the fruit, (3) the proximate subglobose cocci, and (4) the unarmed habit. In contrast to these characters the distinctive features of the second are (1) the biovulate cells of the ovary with plano-convex

[31] Hill, A. W. Proc. Internat. Cong. Pl. Sciences, Ithaca, **2**: 1480–1481, 1486. 1929.

ovules, (2) the seemingly indehiscent, non-circumscissile capsule, each coccus marked with a vertical suture, (3) the divaricate, almost separate, ovoid or obovoid cocci, and (4) the spinose habit.

The fact that the subgenus *Duogyne* has a reduction to two ovules in each cell of the ovary, has a very specialized habit, and has a very limited range in distribution over a relatively recent area geologically, namely, the Mohave Desert and the adjacent region, would indicate that it is the younger of the two subgenera. It should be considered as a subgenus which has been derived through reduction from the older and more widespread *Eumenodora* (fig. 6).

This instance seems to be one, at least, which well illustrates the Age-and-Area hypothesis.[32] The subgenus *Eumenodora* may be interpreted as relatively older than the subgenus *Duogyne.* The former has a much more widespread distribution and a larger number of species and varieties than the latter, being represented in three continents. This situation would suggest that it has had a longer period of evolution than the subgenus *Duogyne.* Further evidence in support of the antiquity of the former subgenus lies in the fact that one of the species belonging to this group, *M. heterophylla,* occurs with its variety in two widely separated continents, namely, North America and Africa. Since this distribution may be explained by the supposition of the existence of a land-bridge forming a ready means of dispersal for species between the continents, it may be supposed that *M. heterophylla* extended from North America to South Africa over the postulated lost continent, Gondwana, before the end of the Cretaceous. If this were true, and there is geological and paleontological evidence for supposing that such may have been the case, then the implication would be that the subgenus *Eumenodora* had been evolved before the obliteration of Gondwana. On the other hand, there is no evidence of glaciation for that portion of Nevada and California in which the single species, *M. spinescens,* and its variety, comprising the subgenus *Duogyne*, occur to indicate that they are relic forms, and, in addition, the region now occupied by this subgenus is a relatively recent one, which facts would lead one to suppose that its present distribution correlated with its repre-

[32] Willis, J. C. Age and area. Cambridge, 1922.

sentation in only one species and variety is a result of its relatively more recent evolution. Finally, the subgenus *Duogyne* shows a reduction from four to two in the number of ovules and seeds in each cell, and this fact, together with those already discussed, would seem to indicate that it is a relatively recent group, having been derived from *Eumenodora*.

Within the subgenus *Eumenodora* certain tendencies are shown. On the one hand, there are those species with pedicels erect in fruit and, on the other, those with the pedicels recurved (fig. 6). Usually, the former species are of erect habit with strict stems, whereas the latter are of more or less decumbent growth with the stems diffuse and spreading. An intermediate condition exists, as would be expected, in which the plants are decumbent with diffuse spreading stems, but have erect pedicels in fruit. An example is *M. integrifolia* var. *trifida*. It would seem that those species with the pedicels recurved in fruit were the more recently evolved, since they manifest a reduced type of inflorescence, the flowers appearing to be solitary, but actually being arranged in a remotely flowered dichasial cyme. They may be considered as having had their inflorescence derived from a well-defined type of dichasial cyme, such as is found in many of those species of the genus, as *M. scabra*, *M. longiflora*, and others.

The recurved-pedicel type is thought to have come from an ancestor, whose condition resembled *M. integrifolia* var. *trifida*, which is an intermediate phase and which in turn may have been derived from a condition similar to that now occurring in *M. integrifolia* (fig. 6). *Menodora helianthemoides* and *M. Coulteri* represent entire-leaved phases of development in the recurved-pedicel group, whereas *M. heterophylla*, *M. pulchella*, and *M. africana* comprise examples of various off-shoots from a pinnatifid-leaved stock.

There occurs, moreover, within the group of erect-pedicel types a series of derivative forms which tend towards successive reduction of foliar organs. A type, such as occurs in *M. scabra*, in which all the leaves are foliose, may be considered as the ancestral form. Variations within this species tend towards a series of branching forms in which the upper leaves become smaller. This branching becomes further manifest in *M. decemfida* and its variety *longifolia*;

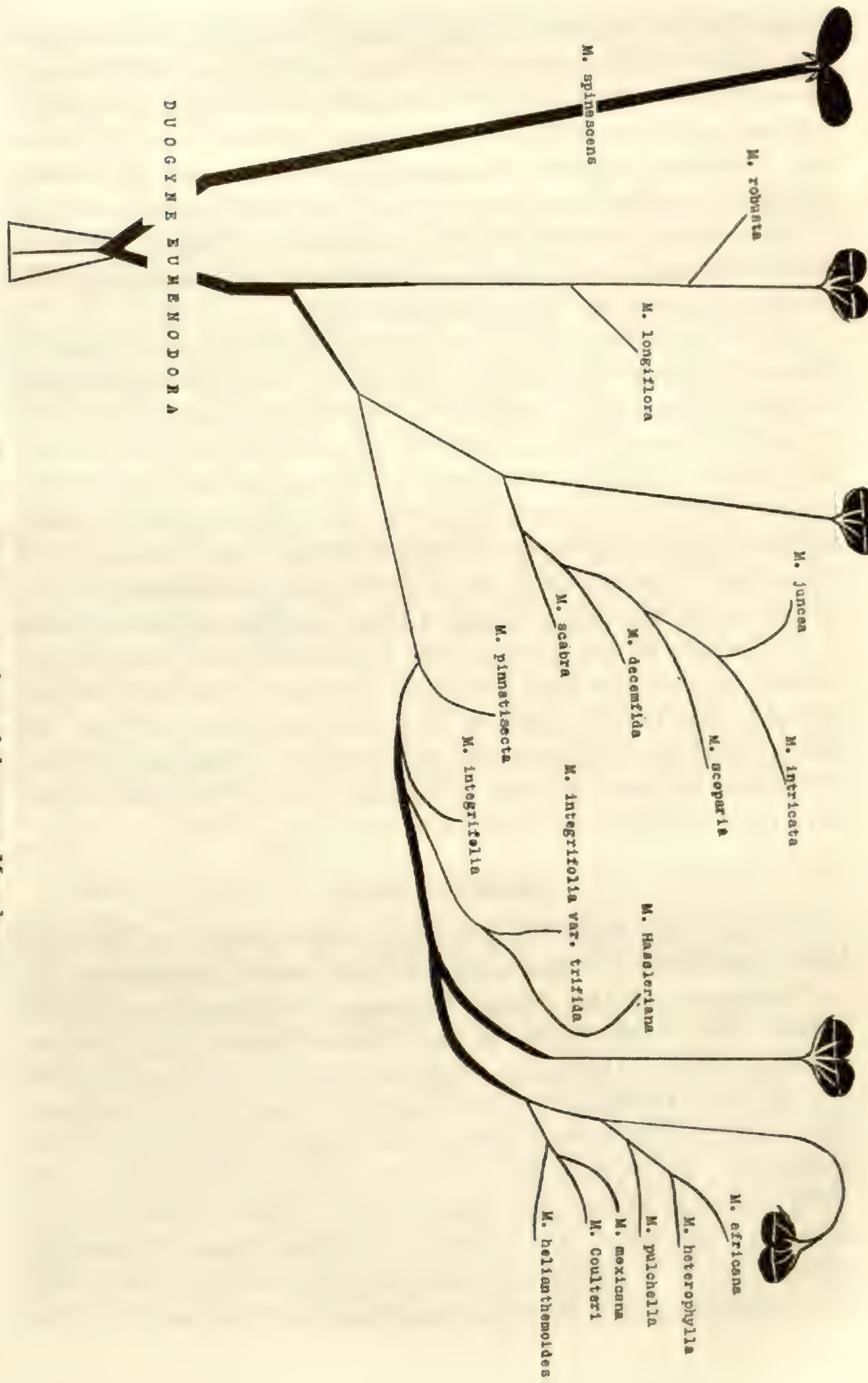

Fig. 6. Phylogenetic chart of the genus *Menodora*.

along with this condition the leaves become farther removed from each other on the elongated internodes, and become rudimentary. It would seem possible, therefore, that *M. scoparia* with the leaves reduced to a rudimentary state has been derived from *M. decemfida*. Further reduction exists in *M. intricata* and its variety *Purpusii* in which all of the leaves have lost their foliose condition, having become reduced to mere rudiments. Finally, reduction becomes extreme in *M. juncea*, in which the leaves are practically obsolete, appearing only as minute scales.

Another tendency within the erect-pedicel group is shown in the corolla characters (fig. 6). One line of development has been towards a long-tubed corolla, with included anthers, such as is found in *M. longiflora*, *M. robusta*, *M. spinescens*, and its variety *mohavensis*. On the other hand, remaining species in the erect-pedicel group have evolved along the line of short-tubed corollas, either subrotate or shortly infundibuliform. In all these forms the orifice of the corolla is pilose within, and the stamens are exserted beyond the tube. The fact that the same condition occurs in all the species belonging to the nodding-pedicel group would indicate that one has been derived from the other; in this instance, probably the nodding-pedicel type has been derived from the erect-pedicel type, because the former shows a reduced inflorescence, and a probably more specialized pedicel that may easily have been derived from the kind found in the latter.

Abbreviations

In citing specimens the following abbreviations for herbaria have been used: A = Herbarium of the Arnold Arboretum; AL = Herbarium of the Albany Museum, Grahamstown, South Africa; AR = Herbarium of the Desert Laboratory, Tucson, Arizona; BER = Herbarium of the Botanical Garden and Museum of Berlin-Dahlem; C = University of California Herbarium; DS = Dudley Herbarium of Stanford University; DUR = Natal Herbarium at Durban, South Africa; F = Herbarium of the Field Museum of Natural History; G = Gray Herbarium of Harvard University; M = Herbarium of the Missouri Botanical Garden; NAT = National Herbarium at Pretoria, South Africa; NY = Herbarium of the New York Botanical Garden; P = Her-

barium of the Philadelphia Academy of Natural Sciences; POM = Herbarium of Pomona College; St. B. = Herbarium of the Santa Barbara Museum; US = Herbarium of the United States National Museum.

TAXONOMY

Menodora Humb. & Bonpl. Pl. Aequin. **2**: 98. *pl. 110.* 1809; Linn. Sp. Pl. [Roem. & Schult.] ed. nov. **1**: 53. 1817; Linn. Syst. Veg. [Spreng.] ed. 16. **1**: 70. 1825; HBK. Nov. Gen. et Sp. Pl. **7**: 199. 1825; D. Don in Edinb. New Phil. Jour. **6**: 48. 1828–29; G. Don, Gen. Hist. Dichl. Pl. **4**: 58. 1838; Griseb. Gen. et Sp. Gentian. 20. 1839; Endl. Gen. Pl. 571. 1841; A. DC. in DC. Prodr. **8**: 316. 1844; A. Gray in Am. Jour. Sci. II. **14**: 43. 1852; Walp. Ann. Bot. **5**: 487. 1858; Harvey, Gen. So. Afr. Pl. ed. 2. 220. 1868; Eichler in Mart. Fl. Bras. **6**: 318. 1868; Benth. & Hook. Gen. Pl. **2**: 674. 1876; A. Gray, Syn. Fl. N. Am. **2**^{1}: 78. 1878; Coulter in Contr. U. S. Nat. Herb. **2**: 261. 1892; Knoblauch in Engler & Prantl, Nat. Pflanzenf. **4**^{2}: 13. 1895; Small, Fl. S. E. U. S. ed. 1. 916. 1903, and ed. 2. 917. 1913; Macloskie in Rept. Princeton Univ. Exp. to Patagonia (Bot.). **8**^{2}: 65. 1905; Harvey in Fl. Cap. **4**: 484. 1909; Arechavelata in Anal. Mus. Nac. Montevideo **7**: 54. 1909; Reiche, Fl. Chile **5**: 103. 1910; Wooton & Standley in Contr. U. S. Nat. Herb. **19**: 497. 1915; Rydberg, Fl. Rocky Mts. 656. 1917, and ed. 2. 656. 1922; Jepson, Man. Fl. Pl. Cal. 760. 1925.

Bolivaria Cham. & Schlecht. in Linnaea **1**: 207. 1826; G. Don, Gen. Hist. Dichl. Pl. **4**: 58. 1838; Griseb. Gen. et Sp. Gentian. 20. 1839; A. DC. in DC. Prodr. **8**: 315. 1844; Schlecht. in Linnaea **26**: 473. 1853.

Calyptrospermum A. Dietrich in Linn. Sp. Pl. [A. Dietrich] ed. 6. **1**: 226. 1831.

Low decumbent, or erect, nearly herbaceous to shrubby and suffruticose, glabrous or pubescent, spinose or unarmed perennials. Leaves alternate or opposite, sessile or petioled, decurrent on the stem, exstipulate, membranaceous, fleshy or subcoriaceous, linear, elliptic-oblong to suborbicular, simple, entire or pinnately bi- to multi-lobed or cleft. Inflorescence centrifugal, in one- to many-flowered corymbose, paniculate, or di- to tri-chasial cymes (when

one-flowered, terminal or axillary in the upper axils). Pedicels recurved or erect in fruit. Calyx gamosepalous, persistent; tube short, turbinate or campanulate, 5–15-parted; lobes setaceous, linear-subulate to cuneate, simple or cleft, glabrous or pubescent, acuminate to obtuse. Corolla gamopetalous, subrotate, campanulate, infundibuliform, or salverform, pilose or glabrous within the throat, the 5–6 lobes imbricate, broadly obovate to narrowly elliptic-oblong, acuminate to obtuse. Stamens 2, inserted near the base or above the middle of the throat of the corolla, included or exserted; filaments long or short, glabrous or pubescent at the base; anthers bilocular, oblong or elliptic-oblong, dorsally attached, basifixed, the cells dehiscing laterally, connective sometimes mucronate at the apex. Ovary superior, obcordate-emarginate, glabrous, inserted on a short gynophore, bilocular. Style filiform, erect, glabrous, about equalling the length of the corolla, longer than the anthers, exserted. Stigma depressed-capitate, slightly obtuse or emarginate. Ovules 4, rarely 2, in each cell, paired, collateral, attached laterally near the middle of the placentae, ascending, descending, or horizontal, anatropous. Capsule didymous, bilocular, membranaceous, glabrous or pubescent, each cell subglobose, ovoid or obovoid, dehiscing circumscissilely, or indehiscent. Seeds usually 4, sometimes 2, in each cell, paired, trigonal or plano-convex, with two coats, the outer spongy with an irregular network, the inner coriaceous, more or less smooth. Endosperm absent. Embryo large, cotyledons flat or plano-convex, radicle short, inferior.

Type species: *Menodora helianthemoides* Humb. & Bonpl. Pl. Aequin. 2: 98. *pl. 110.* 1809.

Key to the Subgenera

A. Plants unarmed (appearing spinescent in *M. robusta*); ovules 4 in each cell; capsule dehiscing circumscissilely, the cocci proximate, more or less globose; seeds trigonal, 4 in each cell. . . *Subgenus Eumenodora* spp. 1–16

AA. Plants spinose; ovules 2 in each cell; capsule not circumscissile, seemingly indehiscent, each coccus marked with a vertical suture or stricture; cocci very divaricate (almost separate), ovoid or obovoid; seeds plano-convex, 2 in each cell. . . . . *Subgenus Duogyne* sp. 17

Key to the Species and Varieties of Menodora

A. Plants diffuse or decumbent; flowers solitary, terminal or axillary, the pedicels recurved in fruit.

a. Leaves entire throughout.
b. Plants always more or less pubescent.
c. Leaves mostly ovate to elliptic-oblong.
d. Stems densely hirsute-pilose, with conspicuous, spreading hairs.
e. Plants 1.2–2.5 dm. high; corolla 12–14 mm. long........... ....*1. M. helianthemoides*
ee. Plants 0.3–0.8 dm. high; corolla 9–12 mm. long............ ....*1a. M. helianthemoides* var. *humilis*
dd. Stems hirtellous-scabrous or scabrous-puberulent, with inconspicuous, short or closely appressed hairs.
e. Corolla 14–17 mm. long ....*1b. M. helianthemoides* var. *magniflora*
ee. Corolla 9–12 mm. long.
f. Stems densely scabrous-puberulent, appearing grayish-white; calyx 3–4 mm. long; mature fruit 5–6 mm. broad. ....*1c. M. helianthemoides* var. *Engelmannii*
ff. Stems sparsely hirtellous-scabrous, with inconspicuous hairs; calyx 5–8 mm. long; mature fruit about 10 mm. broad.................*1d. M. helianthemoides* var. *parviflora*
cc. Leaves mostly linear to oblong-lanceolate.
d. Calyx 5–11 mm. long; corolla 13–17 mm. long........*2. M. Coulteri*
dd. Calyx 3–7 mm. long; corolla 7–8.5 mm. long................ ....*2a. M. Coulteri* var. *minima*
bb. Plants entirely glabrous.............................*3. M. mexicana*
aa. Some or all of the leaves cleft.
b. Leaf-segments narrowly linear, less than 1 mm. broad; calyx-lobes frequently cleft...*4. M. africana*
bb. Leaf-segments lanceolate to obovate, 1–4 mm. broad; calyx-lobes always entire.
c. Calyx-lobes 10–14; leaf-segments lanceolate to oblanceolate, acute; upper leaves frequently entire.
d. Plants mostly diffusely spreading; stems glabrous to slightly scabrous; corolla-lobes slightly or not at all mucronate; upper leaves frequently larger than the lower; leaf below the node subtending the pedicel, equalling or surpassing the calyx; species of North America.....................*5. M. heterophylla*
dd. Plants more or less strict; stems densely scabrous; corolla-lobes mostly conspicuously mucronate; upper leaves smaller and more reduced than the lower; leaf below the node subtending the pedicel not approximating the calyx; species of South Africa.......................*5a. M. heterophylla* var. *australis*
cc. Calyx-lobes 6–7; leaf-segments oblong to obovate, obtuse; upper leaves never entire...............................*6. M. pulchella*
AA. Plants mostly erect; flowers in few- to many-flowered cymes (rarely appearing solitary), the pedicels erect in fruit.
a. Plants unarmed (appearing spinescent in *M. robusta*); ovules 4 in each cell; capsule dehiscing circumscissilely; the cocci proximate, more or less globose; seeds 4 in each coccus.
b. All leaves foliose, the leaf blades well developed.
c. Corolla-tube short, 2.5–7 mm. long, subrotate to shortly infundibuliform, pilose at the orifice.

d. Calyx-lobes 5–6 (rarely 7).
e. Leaves acute.
f. Plants erect; flowers in few to many-flowered cymes... *7. M. integrifolia*
ff. Plants decumbent or diffusely spreading; flowers appearing solitary or in remote dichasial cymes.. *7a. M. integrifolia* var. *trifida*
ee. Leaves obtuse.............................. *8. M. Hassleriana*
dd. Calyx-lobes usually 8–12 (rarely 7).
e. Leaves mostly pinnatisect.................... *9. M. pinnatisecta*
ee. Leaves entire.
f. Plants relatively low, subcaespitose, flax-like; stems mostly simple and subherbaceous.
g. Leaves mostly linear or linear-lanceolate; corolla-lobes oblong to narrowly obovate, obtuse, slightly mucronate.................................. *10. M. scabra*
gg. Leaves mostly ovate, oblong-elliptic, or oblong-lanceolate; corolla-lobes broadly ovate to subovate, acute, distinctly mucronate............ *10a. M. scabra* var. *laevis*
ff. Plants relatively tall; stems very much branched.
g. Leaves mostly elliptic-oblong or oblong-lanceolate.
h. Corolla-tube short, 4.5–5 mm. long....................................... *10b. M. scabra* var. *ramosissima*
hh. Corolla-tube relatively long, 6–7 mm. long................................... *10c. M. scabra* var. *longituba*
gg. Leaves mostly linear or linear-lanceolate.
h. Corolla-lobes oblong-lanceolate, 3–4 mm. broad; corolla-tube about 6 mm. long; species of South America........................... *11. M. decemfida*
hh. Corolla-lobes oblong to obovate, 5–8 mm. broad; corolla-tube 4–5 mm. long; species of Mexico and Texas................. *11a. M. decemfida* var. *longifolia*
cc. Corolla-tube elongated, 25–53 mm. long, salverform, entirely glabrous within.............................. *12. M. longiflora*
bb. Leaves, at least the upper ones, bracteate, becoming rudimentary.
c. Upper leaves bracteate, becoming rudimentary, lower leaves foliose.. *13. M. scoparia*
cc. All of the leaves bract-like, the leaf blades much reduced.
d. Corolla-tube short, 4–5 mm. long.
e. Stems very much ribbed and intricate; calyx-lobes 7–11; species of North America.
f. Plants mostly glabrous, 2.5–4 dm. high; corolla 10–12 mm. long... *14. M. intricata*
ff. Plants scabrous, 0.6–1.2 dm. high; corolla 8–10 mm. long. .... *14a. M. intricata* var. *Purpusii*
ee. Stems not conspicuously ribbed and intricate; calyx-lobes 5; species of Africa.......................... *15. M. juncea*
dd. Corolla-tube elongated, about 12 mm. long........... *16. M. robusta*

aa. Plants spinose; ovules 2 in each cell; capsule not circumscissile, seemingly indehiscent, each coccus marked with a vertical suture or stricture; cocci strongly divaricate (almost separate), ovoid or obovoid; seeds 2 in each coccus.
  b. Corolla-tube 4–6 mm. long, narrowly infundibuliform, more or less abruptly expanded at the orifice.................... *17. M. spinescens*
  bb. Corolla-tube 10–12 mm. long, broadly infundibuliform, gradually ampliated at the orifice............ *17a. M. spinescens* var. *mohavensis*

1. M. helianthemoides Humb. & Bonpl. Pl. Aequin. **2**: 98. *pl. 110.* 1809; Planches de Bot. **4**: *pl. 103.* 1823; Kunth in HBK. Nov. Gen. et Sp. Pl. **7**: 199. 1825; G. Don, Gen. Hist. Dichl. Pl. **4**: 58. 1838; Steud. Nom. Bot. ed. 2. **2**: 124. 1841; A. DC. in DC. Prodr. **8**: 316. 1844; A. Gray in Am. Jour. Sci. II. **14**: 44. 1852; Walp. Ann. Bot. **5**: 487. 1858; Hemsl. Biol. Cent.-Am. Bot. **2**: 304. 1881, and **4**: 67. 1886; S. Watson in Proc. Am. Acad. **18**: 112. 1883; Knobl. in Engler & Prantl, Nat. Pflanzenf. **4²**: 14. 1895; Standl. in Contr. U. S. Nat. Herb. **23**: 1138. 1924.

A branching, decumbent, suffruticose perennial, 1.2–2.5 dm. high; stems numerous, slender, slightly angled, divergently and diffusely spreading, opposite, and conspicuously and densely hirsute-pilose; leaves opposite, numerous, crowded, slightly petiolate, oblong-elliptic to suborbiculate, including the petiole, 5–22 mm. long, 3–10 mm. broad, obtuse, mucronate, entire, densely hirsute-pilose, submembranaceous; flowers large, relatively few, solitary, terminal, in remotely flowered dichasial cymes; pedicels slender, 5–10 mm. long, densely hirsute-pilose, recurved in fruit; calyx campanulate, 8–14 mm. long, hirsute-pilose; calyx-tube 1.5–2 mm. long, in anthesis 1.5–2 mm. broad, in fruit about 3 mm. broad; lobes 10–13, equal or unequal, setaceous, linear-lanceolate to linear-spatulate, acute to acuminate, entire, 7–10 mm. long, 0.25–1.3 mm. broad; corolla shortly infundibuliform or subrotate, 12–14 mm. long, golden yellow; corolla-tube short, 3–4 mm. long, about 4 mm. broad at the orifice, densely pilose within; lobes 5, elliptic-oblong, obtuse or slightly acutish, 10–12 mm. long, about 4 mm. broad, irregularly hirsute-pilose without; stamens exserted, 7–10 mm. long; filaments glabrous, slightly mucronate at the apex; pollen grain finely reticulated, (72.5); 75–93.75; (100.0) μ in diameter; pistil about 10 mm. long; ovules 4 in each cell; stigma broadly capitate; capsule 7–8 mm. long, about 10–12

mm. broad; seeds 4 in each cell, finely and irregularly reticulate, about 5 mm. long, 3 mm. broad.

Distribution: southeastern Mexico.

Specimens examined:

MEXICO:

PUEBLA: in vicinity of San Luis Tultitlanapa, near Oaxaca, June, 1908, *Purpus 3392* (C, F, G, M, NY, US); El Riego, June, 1905, *Purpus 1319* (C, F, G, M, NY); near Tehuacan, Aug. 1 and 2, 1901, *Rose & Hay 5931* (US).

1a. Var. **humilis** Steyermark, n. var.[33]

A dwarf suffruticose perennial, 0.3–0.8 dm. high; leaves, including the petiole, 2–11 mm. long, 1–5 mm. broad, acute; calyx 4–7 mm. long, lobes 2–6 mm. long; corolla 9–12 mm. long, with the lobes 8–10 mm. long; capsule 5–6 mm. long, 9–10 mm. broad. In other respects similar to the species.

Distribution: San Luis Potosi, Mexico.

Specimens examined:

MEXICO:

SAN LUIS POTOSI: region of San Luis Potosi, 22° N. Lat., alt. 1829–2439 m., 1878, *Parry & Palmer 571*, in part (F, G, M, TYPE) and *570*, in part (F).

1b. Var. **magniflora** Steyermark, n. var.[34]

Stems moderately scabrous; leaves 5–16 mm. long, 1.5–6 mm. broad, scaberulent; calyx moderately scabrous; corolla 14–17 mm. long, lobes broadly ovate, 13–14 mm. long, 7–9 mm. broad; capsule 8–9 mm. long, about 15 mm. broad.

In other respects similar to the species.

Distribution: San Luis Potosi, Mexico.

[33] Var. **humilis** Steyermark, var. nov., humilis, suffruticosa, perennis, 0.3–0.8 dm. alta; foliis, petiolis includentibus, 2–11 mm. longis, 1–5 mm. latis, calyce 4–7 mm. longo, lobis 2–6 mm. longis; corolla 9–12 mm. longa, lobis 8–10 mm. longis; capsula 5–6 mm. longa, 9–10 mm. lata.—TYPE collected in region of San Luis Potosi, state of San Luis Potosi, Mexico, alt. 1829–2439 m., 1878, *Parry & Palmer 571*, in part (M).

[34] Var. **magniflora** Steyermark, var. nov., caulibus moderate scabrosis; foliis 5–16 mm. longis, 1.5–6 mm. latis, scaberulentis; calyce moderate scabroso; corolla 14–17 mm. longa, lobis late obovatis, 13–14 mm. longis, 7–9 mm. latis; capsula 8–9 mm. longa, circiter 15 mm. lata.—TYPE collected in region of San Luis Potosi, state of San Luis Potosi, Mexico, alt. 1829–2439 m., 1878, *Parry & Palmer 570*, in part (M).

Specimens examined:

MEXICO:

SAN LUIS POTOSI: in region of San Luis Potosi, 22° N. Lat., alt. 1829–2439 m., 1878, *Parry & Palmer 570*, in part (F, G, M TYPE, P, US); San Luis Potosi, 1877, *Schaffner 503* (NY); in montibus, Morules, San Luis Potosi, Sept., 1876, *Schaffner* (NY); San Luis Potosi, 1878, *Schaffner 68* (NY); 1879, *Schaffner 503* (US); in montibus prope Morules, ex convalli San Luis Potosi, October, 1876, *Schaffner 68* (G).

WITHOUT LOCALITY: *Coulter 937* (G); des collines de la Presa, 1902, *Dugès 18* (G).

1c. Var. **Engelmannii** Steyermark, n. var.[35] Pl. 5, fig. 1

A dwarf suffruticose perennial, 0.4–0.6 dm. high; stems densely scaberulent, appearing grayish-white; leaves ovate to linear-lanceolate, including the petiole, 2.5–8 mm. long, 1–3 mm. broad, acute; pedicels scaberulent; calyx 3–4 mm. long, slightly scabrous, lobes 2.5–3 mm. long; corolla 10–11 mm. long, lobes 6–7 mm. long; capsule about 4 mm. long, about 5–6 mm. broad.

In other respects similar to the species.

The type of this variety, a plant collected by Gregg in Saltillo, Mexico, in 1848, was designated and described in manuscript as a new species by Dr. George Engelmann.

Distribution: southern Coahuila to Hidalgo, Mexico.

Specimens examined:

MEXICO:

COAHUILA: valley near Saltillo, May 7, 1848, *Gregg 44* (G, M TYPE); Saltillo, 1898, *Ed. Palmer 164* (C, F, M, NY, US).

SAN LUIS POTOSI: region of San Luis Potosi, 22° N. Lat., alt. 1829–2439 m., 1878, *Parry & Palmer 571*, in part (F, G, M).

HIDALGO: Ixmiquilpan, *Rose, Painter & Rose 9007* (NY).

ZACATECAS: arroyos in hills, Cedros, July, 1908, *Lloyd 140* (US).

[35] Var. **Engelmannii** Steyermark, var. nov., humilis, suffruticosa perennis, 0.4–0.6 dm. alta; caulibus scaberulentissimis, cinereo-albidis; foliis ovatis vel lineari-lanceolatis, petiolis includentibus, 2.5–8 mm. longis, 1–3 mm. latis, acutis; pedicellis scaberulentis; calyce 3–4 mm. longo, subscabroso, lobis 2.5–3 mm. longis; corolla 10–11 mm. longa, lobis 6–7 mm. longis; capsula 4 mm. longa, 5–6 mm. lata.—TYPE collected in valley, near Saltillo, state of Coahuila, Mexico, May 7, 1848, *Gregg 44* (M).

1d. Var. **parviflora** Greenman in Proc. Am. Acad. **34:** 569. 1899.

A decumbent suffruticose perennial, 0.4–2 dm. high, more or less hirtellous-scabrous throughout, with inconspicuous hairs; leaves slightly fleshy, including the petiole, 5–19 mm. long, 1.5–6 mm. broad, acute; calyx 5–8 mm. long, lobes 3–6 mm. long, 0.3–1 mm. broad; corolla 9–12 mm. long, with 5 narrowly oblong, acutish lobes 7–8 mm. long, 3–4 mm. broad; corolla-tube 4–5 mm. long, about 2–3 mm. broad at the orifice; stamens 7–8 mm. long; anthers conspicuously mucronate at the apex; pistil about 8 mm. long; capsule about 6 mm. long, about 10 mm. broad.

Distribution: Hidalgo and Puebla, Mexico.

Specimens examined:

Mexico:

Hidalgo: bare hills above Pachuca, alt. 2591 m., July 30, 1896, *Pringle 6918* (C, F, G type, M, NY, P, Pom, US); Pachuca, alt. 2134–2439 m., July, 1903, *Purpus 437* (M, C, Pom, US), and *434*, in part (C); between Pachuca and Real del Monte, July 19, 1905, *Rose, Painter & Rose 8712* (US).

Puebla: Moria, 1800 m., June, 1909, *Arsène* (F).

2. M. Coulteri A. Gray in Am. Jour. Sci. II. **14:** 44. 1852; Walp. Ann. Bot. **5:** 487. 1858; Hemsl. Biol. Cent.-Am. Bot. **2:** 304. 1881; S. Watson in Proc. Am. Acad. **18:** 112. 1883; Standl. in Contr. U. S. Nat. Herb. **23:** 1138. 1924.

A branching, decumbent or somewhat erect, suffruticose perennial, 1.5–2 dm. high; stems opposite, numerous, slender, more or less terete, divergently and diffusely spreading to erect, usually scaberulent; leaves opposite, numerous, rather crowded, subcoriaceous, narrowed at the base into a short petiole, linear to oblanceolate, including the petiole, 2–18 mm. long, 1–3 mm. broad, acute to acuminate, entire, glabrous or sparsely scaberulent; flowers large, relatively few, solitary, terminal; pedicels slender, 3–10 mm. long, glabrous or slightly roughened, recurved in fruit; calyx campanulate, 5–11 mm. long, glabrous or sparsely scaberulent; calyx-tube 1.3–2 mm. long, in anthesis 1.1–2 mm. broad, in fruit 2–3 mm. broad, mostly glabrous, sometimes sparsely scaberulent; lobes 10–15, linear, entire, setiform, acuminate, 4–10

mm. long, 0.2–0.5 mm. broad, sparsely hirtellous on the margins; corolla subrotate, 13–17 mm. long; corolla-tube short, 3–5 mm. long, 3–4 mm. broad at the orifice, densely pilose within; lobes 5–6, oblong or elliptic, obtuse, 10–13 mm. long, 4–6 mm. broad; stamens exserted, 7–9 mm. long; filaments glabrous, anthers slightly mucronate at the apex, the connective prolonged into a short, cylindrical protuberance; pollen grain finely and regularly reticulated, (75); 93.75–106.25; (112.5) μ in diameter; pistil about 10–14 mm. long; ovules 4 in each cell; stigma broadly capitate; capsule 5–6 mm. long, about 10 mm. broad; seeds 4 in each cell, rather finely and irregularly reticulated, about 4 mm. long, 1.5–2 mm. broad.

Distribution: Coahuila and Nuevo Leon to Hidalgo, Mexico.

Specimens examined:

MEXICO:

NUEVO LEON: Jasmincillo del Monte, 15 mi. w. of Icamole, Feb. 3, 1907, *Safford 1263* (US).

SAN LUIS POTOSI: in region of San Luis Potosi, 22° N. Lat., alt. 1829–2439 m., 1878, *Parry & Palmer 571*, in part (US).

HIDALGO: Zimapan, *Coulter 938* (G TYPE); rocky slopes, Ixmiquilpan, Aug. 1905, *Purpus 1447* (C, F, G, M, NY, Pom); near Ixmiquilpan, 1905, *Rose, Painter & Rose 8311* (US).

COAHUILA: Saltillo, April 15–30, 1898, *Ed. Palmer 34* (C, F, G, M, NY, US).

2a. Var. **minima** Steyermark, n. var.[36]

Leaves lanceolate to ovate-lanceolate, including the petiole, 2–6 mm. long, 1–2 mm. broad; flowers small; calyx 3–7 mm. long, lobes 2–6 mm. long; corolla 7–8.5 mm. long, lobes about 5 mm. long, 2.5–3 mm. broad, mucronate; stamens about 6 mm. long; pistil about 7 mm. long.

In other respects similar to the species.

Distribution: Coahuila and Nuevo Leon south to south-central Mexico.

[36] Var. **minima** Steyermark, var. nov., foliis lanceolatis vel ovato-lanceolatis, petiolis includentibus, 2–6 mm. longis, 1–2 mm. latis; floribus minimis; calyce 3–7 mm. longo, lobis 2–6 mm. longis; corolla 7–8.5 mm. longa, lobis circiter 5 mm. longis, 2.5–3 mm. latis, mucronatis; staminibus circiter 6 mm. longis; pistillo circiter 7 mm. longo.—TYPE collected near Arroyos, Cedros, state of Zacatecas, June, 1908, *Kirkwood 20* (M).

Specimens examined:

Mexico:

Coahuila and Nuevo Leon: Feb.–Oct., 1880, *Ed. Palmer* (G, P).

San Luis Potosi: in region of San Luis Potosi, 22° N. Lat., alt. 1829–2439 m., 1878, *Parry & Palmer 571*, in part (M) and *300½* (G).

Zacatecas: near arroyos, Cedros, June, 1908, *Kirkwood 20* (F, M type).

Hidalgo: rocky slopes, Ixmiquilpan, Aug. 1905, *Purpus 1447* (G, POM); Pachuca, alt. 2134–2439 m., 1903, *Purpus 434*, in part (C).

Without Locality: Sierra de la Paila, Oct., 1910, *Purpus 5020* (C).

3. **M. mexicana** (A. DC.) A. Gray in Am. Jour. Sci. II. **14**: 45. 1852; Walp. Ann. Bot. **5**: 488. 1858; Hemsl. Biol. Cent.-Am. Bot. **2**: 304. 1881; Standl. in Contr. U. S. Nat. Herb. **23**: 1138. 1924.

Bolivaria Mexicana A. DC. in DC. Prodr. **8**: 315. 1844.

A nearly herbaceous, erect perennial, about 1.5 dm. high; stems numerous, slender, strict, angled, glabrous; leaves not crowded, opposite, slightly petiolate, linear to oblong-lanceolate, including the petiole, 6–17 mm. long, 1–5 mm. broad, entire, acute, glabrous, subcoriaceous; flowers few, solitary, terminal; pedicels slender, 6–17 mm. long, glabrous, recurved in fruit; calyx campanulate, 10–12 mm. long, glabrous; calyx-tube about 3 mm. long, in anthesis about 2 mm. broad, in fruit about 4 mm. broad, glabrous; lobes 10–12, linear, setiform, acuminate, 5–10 mm. long, 0.2–0.5 mm. broad, glabrous; corolla subrotate, 13–15 mm. long; corolla-tube short, about 3 mm. long, about 4 mm. broad at the orifice, pilose within; lobes 5, elliptic-oblong, obtuse, mucronate, 10–12 mm. long, 5–6 mm. broad; stamens exserted, about 10 mm. long; pistil about 12 mm. long; stigma capitate; capsule about 6 mm. long, 10–12 mm. broad.

Distribution: Oaxaca, Mexico.

No specimens seen. Description compiled.

Mexico: near Oaxaca, July, *Andrieux 228* (Herb. DC. type, M photograph of type).

4. M. africana Hooker in Hook. Ic. Pl. *pl. 586.* 1842; A. Gray in Am. Jour. Sci. II. **14**: 44. 1852; Walp. Ann. Bot. **5**: 487. 1858; Knobl. in Engler & Prantl, Nat. Pflanzenf. 4^2: 14. 1895; Wood, Natal Pl. 3^2: 17. *pl. 240.* 1902; Harvey in Fl. Cap. **4**: 484. 1907. Pl. 4, fig. 2; pl. 5, fig. 2.

An erect or slightly decumbent, nearly herbaceous perennial, 0.6–2.5 dm. high; stems numerous, diffuse, freely branched, mostly terete, sparingly to densely scabrous; leaves opposite or alternate, numerous, fleshy, subsessile to distinctly petiolate, including the petiole, 3–10 mm. long, about 4–6 mm. broad, multifid, heather-like, the segments narrowly linear, 1–5 mm. long, about 0.3 mm. broad, acute, glabrous or slightly scabrous on the margins; flowers relatively numerous, pedicels solitary, terminal, slender, 5–10 mm. long, scabrous, recurved in fruit; calyx campanulate, 5–11 mm. long, glabrous to densely scabrous; calyx-tube about 1–3 mm. long, about 2 mm. broad, becoming 4 mm. broad in fruit; lobes 10–14, narrowly linear, acute, entire or cleft, 4–7 mm. long, 0.3 mm. broad; corolla subrotate, 11–17 mm. long, yellow, corolla-tube short, 2–3.5 mm. long, pilose at the orifice within; lobes 5, obovate, obtuse, slightly to conspicuously mucronate, 8–12 mm. long, 4–7 mm. broad; stamens exserted, 8–10 mm. long; filaments glabrous, connective not prolonged at the apex; pollen grain small, very finely and regularly reticulated, 48.75–56.25; (63.75) μ in diameter; pistil 9–14 mm. long; ovules 4 in each cell; stigma small, capitate; capsule 7–8 mm. long, 12–15 mm. broad; seeds usually 2 or 3 in each cell, one or more failing to develop, about 8 mm. long, about 4.5 mm. broad.

Distribution: South Africa, from the Kalahari Desert region east to Transvaal and Natal and south to the Cape Province.

Specimens examined:

AFRICA:

UNION OF SOUTH AFRICA:

CAPE PROVINCE: Tÿger Kop, Hay district, Feb. 1927, *Wilman* (AL).

NATAL: near Dundee, alt. 1220–1525 m., Nov. 1896, *Pegler* (NAT); Leeuwport, Oct. 1918, *Rogers 22393* (DUR); in graminosis near Colenso, alt. 1500 m., Sept. 27, 1893, *Schlechter 3369* (AL, BER); ½ mile from Syndicate Farm, Dundee, Indumeni Mt.,

alt. 1311.5 m., March 10, 1926, *Truscott 157* (NAT); bank of Tugela, Weenen Co., alt. 1220 m., Jan. 2, 1886, *Wood 3550* (DUR); bank of Tugela near Colenso, alt. 915 m., Oct. 23, 1888, *Wood 758*, and alt. 1220 m., *Wood 758* (BER); ad ripas fluminis, Tugela River, near Colenso, alt. 915 m., Oct. 1888, *Wood* (AL); Wagon Hill, near Ladysmith, alt. 915–1220 m., Nov. 27, 1900, *Wood 7948* (F, P); near Ladysmith, alt. 1006.5 m., Feb. 14, 1895, *Wood 5506* (M).

Orange Free State: Kimberly, July, 1912, *Moran 86* (AL); Kroonstad, Oct. 1929, *Port 228* (NAT).

Transvaal: Town Commonage, Christiana, District Bloemhof, Feb. 14, 1912, *Burtt-Davy 12480* (NAT); Vaal River, near Hebron, alt. 1159 m., 1892, *Flanagan 1472* (NAT); slopes between Kaap and Crocodile Rivers, alt. 610 m., Sept. 28, 1890, *Galpin 1071* (AL); grassy plains, Queen's River, Barberton, alt. 610 m., Nov. 15, 1890, *Galpin 1071* (NAT); plains near Crocodile Poort, alt. 610 m., Sept. 28, 1890, *Galpin 1071* (US); Vereeniging, alt. 1448.75 m., Nov.–Dec., 1898, *Gilfillan 148* (NAT); Modderfontein, Dec., 1904, *Haagner* (AL); Bloemhof, Nov. 1916, *Miss Lloyd* (AL); Arcadia, Pretoria, Nov. 29, 1915, *Murray* (NAT); Hatherly, March 20, 1905, *Rogers 109* (AL); Arcadia, Pretoria, Nov. 11, 1913, *Stent 9563* (NAT); on flats near Barberton, alt. 762.5 m., Oct. 1906, *Thorncroft 646* (DUR); Onderstepoort, Pretoria, *Veterinary Research Laboratory 25* (NAT); near Lydenburg, Oct. 1887, *Wilms* (BER).

Kalahari Region: Derde Poort, Oct. 18, 1904, *Leendertz 369* (AL).

British Bechuanaland: Armoed's Vlakte, Vryburg, alt. 1207.8 m., Oct. 7, 1920, *Mogg 8024* (NAT).

Griqualand West: in arenosis, Barkly-west, alt. 1200 m., Feb. 1886, *Marloth 258* (BER).

Without State: *Burchell 2478, 2960* (G); March, 1920, *Elliott* (NAT); *Government Herbarium, Department of Agriculture 14389* (NAT); February, 1920, *Moran* (NAT).

5. **M. heterophylla** Moric. ex A. DC. in DC. Prodr. **8**: 316. 1844; A. Gray in Am. Jour. Sci. II. **14**: 44. 1852; Walp. Ann. Bot. **5**: 487. 1858; A. Gray, Syn. Fl. N. Am. 2^1: 78. 1878;

Hemsl. Biol. Cent.-Am. Bot. **2**: 304. 1881; Oliver in Hook. Ic. Pl. III. **5**: 47. *pl. 1459.* 1884; Coulter in Contr. U. S. Nat. Herb. **1**: 43. 1890, and **2**: 261. 1892; Knobl. in Engler & Prantl, Nat. Pflanzenf. **4**^{2}: 14. 1895; Harvey in Fl. Cap. **4**: 484. 1907; Small, Fl. S. E. U. S. ed. 1. 916. 1903, and ed. 2. 917. 1913; Standl. in Contr. U. S. Nat. Herb. **23**: 1137. 1924.

Pl. 4, figs. 11–12; pl. 6, fig. 1.

M. pinnatifida Mart. in Ann. Sci. Nat. Bot. III. **19**: 365. 1853.

Bolivaria Grisebachii Scheele in Linnaea **25**: 254. 1852.

B. pinnatifida Schlecht. in Linnaea **26**: 474. 1853.

A diffuse, decumbent, subherbaceous perennial, 0.4–2.5 dm. high; stems numerous, slender, slightly angled, sparsely hispidulous; leaves opposite, slightly petiolate, numerous, crowded, submembranaceous, linear to oblong-lanceolate, acute, entire or pinnately 3–7-cleft or -lobed, including the petiole, 5–40 mm. long, 2–30 mm. broad, the segments linear-lanceolate to obovate, 3–25 mm. long, glabrous except for the slightly hirtellous margins; flowers relatively few, pedicels solitary, terminal, slender, 5–8 mm. long, scaberulent, recurved in fruit; calyx campanulate, 6–11 mm. long; calyx-tube 1–3 mm. long, in anthesis about 1.5–2 mm. broad, in fruit 4–5 mm. broad, scaberulent; lobes 10–14, linear, acute, entire, 5–10 mm. long, 0.5–1 mm. broad, hirtellous on the margins; corolla shortly infundibuliform, 8–17 mm. long, light yellow to reddish-purple; corolla-tube short, 2–5 mm. long, about 5 mm. broad at the orifice, sparsely pilose near the base of the throat within; lobes 5–6, obovate, 6–12 mm. long, 3.5–6 mm. broad, obtuse, slightly mucronate; stamens exserted, about 8–10 mm. long; filaments glabrous, connective not conspicuously prolonged at the apex; pollen grain moderately and regularly reticulated (67.25); 75–83.75; (90.0) μ in diameter; pistil about 10 mm. long; ovules 4 in each cell; stigma capitate; capsule 6–10 mm. long, 10–18 mm. broad; seeds 4 in each cell, 5–7 mm. long, about 4 mm. broad, coarsely and rather irregularly reticulated.

Distribution: central Texas south to Nuevo Leon and Tamaulipas, Mexico.

Specimens examined:

UNITED STATES:

TEXAS: in field, San Antonio, Aug. 23, 1906, *Ball 955* (US);

between Laredo and Bejar, 1828, *Berlandier 1461* (M); Arica, Nov. 1828, *Berlandier 516* (G); *Bigelow 79* (F); sandy soil, Austin, Feb. 1890, *Bodin* (M); Llano, May 12–15, 1899, *Bray 319* (US); common in barrens, San Antonio, March 24, 1902, *Bush 1181* (G, M, US); Spofford Junction, March 21, 1900, *Canby 162½* (G, P, US); tropical life zone, Bexar Co., April 17, 1911, *Clemens & Clemens 488* (C, M, POM); tropical life zone, San Antonio, Bexar Co., April 19, 1911, *Clemens & Clemens 490* (M, POM); tropical life zone, San Antonio, Bexar Co., June 20, 1911, *Clemens & Clemens 489* (POM); San Diego, 1884, *Croft 13* (NY); Painted Cave, Rio Grande River, March 12, 1893, *Davy 41* (C); Spofford Junction, March 12, 1893, *Davy 30* (C); along railroad, Victoria, Victoria Co., April 7, 1900, *Eggert* (G, M); hills, Austin, May 17, 1872, *Hall 293* (F, M, NY, POM, US); Corpus Christi, Nueces Co., alt. 0–12.2 m., March 5–12, 1894, *Heller 1390* (C, G, M, NY, P, US); 1894, *Heller* (US); Calallen, March 26, 1920, *High 80* (M); Bexar Co., 1903, *Jermy 55* (M, NY, US); Bexar Co., 1904, *Jermy 35* (NY); San Antonio, *Jermy 164* (G); San Antonio, *Jermy 262* (G); Threadgill Valley, Gillespie Co., *Jermy 447* (US); San Antonio, *Jermy* (NY, US); Del Rio, April 20, 1930, *M. E. Jones 26718* (M); Lampasas, Oct. 29, 18—, *Joor* (M); San Antonio to Laredo, March 26, 1885, *Kiddes* (G, US); Reynoldsville, Cameron Co., April 13, 1905, *Lewton 176* (US); April, 1828, *Lindheimer* (M); 1849–51, *Lindheimer* (POM); New Braunfels, 1846, *Lindheimer 454* (C, F, G, M, P, US); arid soil on the Cibolo, July, 1847, *Lindheimer 454* (M), *42?* (G); on clayey soil, Agua Dulce, Matagorda, Feb. 1845, *Lindheimer 383a* (G); Guadeloupe, Victoria, Feb. 1845, *Lindheimer 383c* (M); 15 mi. w. of New Braunfels, Oct. 1846, *Lindheimer 218* (G); 1846, *Lindheimer 455* (C, G, P); Ballinger, 1889, *Nealley 378a* (US); Roma, 1889, *Nealley 262* (US); Corpus Christi, May, 1913, *Orcutt 5858* (M); Laredo, Feb.–March, 1913, *Orcutt 5594* (M); southwest Texas, Sept. 1879–Oct. 1880, *Ed. Palmer 791* (US); southwest Texas, Sept. 1879–Oct. 1880, *Ed. Palmer 790* (US); San Antonio, Sept. 1879, *Ed. Palmer 790* (G, P); Laredo, Rio Grande River, 180 miles from San Antonio, Aug. 1–20, 1879, *Ed. Palmer 791* (M); Sutherland Springs, Wilson Co., Aug. 1879, *Ed. Palmer 791* (G); dry open ground, Corpus Christi, Nueces Co., March 8, 1917, *E. J. Palmer 11214* (M); dry

open ground, calcareous soil, Sweetwater, Nolan Co., May 27, 1918, *E. J. Palmer 13726* (M); dry calcareous soil, Sabinal, Uvalde Co., June 8, 1916, *E. J. Palmer 10118* (M); dry calcareous soil, San Antonio, March 16, 1916, *E. J. Palmer 9178* (M); dry rocky ground, near Uvalde, Uvalde Co., April 28, 1928, *E. J. Palmer 33608* (M); Mexican Boundary Survey, *Parry, Bigelow, Wright & Schott 1101* (NY); Marble Falls, Aug. 10, 1892, *Plank* (NY); Del Rio, Dec. 7, 1891, *Plank* (NY); sandy prairies, Brown Co., April, 1882, *Reverchon 1328* (US); sandy soils, Brown to Tom Green Co., up to Callahan, April, 1882, *Reverchon 1328* (F, M); dry soils, Kimble Co., May, 1885, *Reverchon 1328* (C, F, G, M, NY, US); Tamarcensis, *Riddell* (NY); sandy soil, Loma Alta, alt. 9.15 m., June 1, 1923, *Runyon 548* (US); western Texas, *Schott* (F); *Schott 3344* (F); San Marcos and vicinity, spring of 1897, *Stanfield* (NY); chaparral, 5 mi. w. of Del Rio, Valverde Co., June 9, 1931, *Moore & Steyermark 3006* (M); Colorado, May 16, 1908, *Tracy 8087* (F, G, NY, US); Spofford, April 7, 1900, *Trelease 26* (M); vicinity of San Antonio, April, 1919, *von Schrenk 1* (M); San Antonio, 1900, *Wilkinson 7* (M); San Antonio, 1897, *Wilkinson 7* (M); Reynoldsville, April 15, 1905, *Williamson 176* (P); *Wright* (NY); May–Oct. 1849, *Wright 562* (F, G, US); near Austin, Oct. 12, 1913, *Young* (M); abundant in dry open ground, university campus, Austin, March 22, 1918, *Young* (G).

MEXICO:

TAMAULIPAS: dry valley, east of Camargo, June 1, 1847, *Gregg 883* (G, M, NY); San Fernando to Jimenez, Feb. 26–27, 1902, *Nelson 6602* (G, US); vicinity of Victoria, alt. 320 m., Feb. 1–April 9, 1907, *Ed. Palmer 85* (C, F, M, US); 25 miles south of Matamoros, June 29, 1919, *Wooton* (US).

NUEVO LEON: valley, Monterey, July 29, 1889, *Pringle 2408* (C, F, M, NY, P, US); El Carriro, near Monterey, Sept. 4, 1904, *Pringle 13456* (US).

5a. Var. **australis** Steyermark, n. var.[37] Pl. 6, fig. 2.

A relatively strict perennial, 0.7–1.3 dm. high; stems harshly

[37] Var. **australis** Steyermark, var. nov., relative stricta perennis, 0.7–1.3 dm. alta; caulibus aspere scabris; foliis minoribus et reductioribus, 3–16 mm. longis, 1–7 mm. latis, scabrioribus; pedicellis dense scabris; calycis lobis 2–8 mm. longis, scabris; corollae lobis plerumque manifeste mucronatis.—TYPE collected on grassy turf, near Rustenburg, alt. 1220 m., Aug., 1903, *Pegler 950* (BER).

scabrous; leaves smaller and more reduced, 3–16 mm. long, 1–7 mm. broad, the segments 2–7 mm. long, more scabrous; pedicels densely scabrous; calyx-lobes 2–8 mm. long, scabrous; corolla-lobes mostly conspicuously mucronate.

Distribution: Transvaal and Kalahari region, South Africa.

The opinion has been generally held in the past that this South African plant was conspecific with the North American *M. heterophylla*. Oliver,[38] describing and illustrating the South African plant for the first time from material collected in the Transvaal, Matebe Valley, by Dr. Holub, considered it as conspecific with the plant from the New World, stating, "although we have no fruiting specimens from South Africa, yet there seems no ground to doubt the identity of this Transvaal plant . . . with North American specimens of which we have an ample series," and "now the interest of the case is heightened by Dr. Holub's discovery of a second South African species actually conspecific with a North American one."

Although the Old and the New World plants, in general, show striking similarity, yet careful examination reveals several points of difference. The American plant is, on the average, taller, more diffusely spreading than the dwarfed, stricter African specimen. The leaves of the former are generally larger and more scabrous than those of the latter. The upper leaves of the American plant are frequently much larger than those lower on the cauline axis, whereas in the African plant the upper leaves are usually smaller and more reduced, but never larger, than those lower on the stem. Further, the stems and pedicels of the African plant are decidedly more densely scabrous with larger excrescences than those of the American specimen. Also, the corolla-lobes of the latter are, at the most, only slightly mucronate, whereas those of the African plant are generally conspicuously mucronate. Finally, it is to be noted that in the American plant the leaf immediately below the node subtending the pedicel of the flower constantly equals or surpasses the calyx, whereas in the African plant the leaf in the same position never approximates the calyx.

This is a very striking instance, seemingly, of parallel development, and, although there are morphological differences existing

[38] Oliver in Hook. Icon. III. **5:** 47. *pl. 1459.* 1884.

between these plants, they do not seem to the writer of distinct or sufficiently large import to warrant specific differentiation.

Specimens examined:

South Africa:

Transvaal: Klerksdorp, Cape Province, Nov., *Convent Sisters 28* (AL); grassy plains near race course, Rustenburg, June 11, 1928, *Galpin 9668* (NAT); on the border between Marico and Rustenburg district, near Wonderfontein, Oct. 25, 1907, *Gray 4131* (NAT); Klerksdorp, Cape Province, Jan. 1913, *Lucy 11* (AL); turf, from Pretoria to Woodstock, Rustenburg, alt. 1220 m., Sept. 17, 1903, *Pegler 950* (AL, NAT); grassy turf, near Rustenburg, alt. 1220 m., Aug. 1903, *Pegler 950* (BER type); grassy turf, near Rustenburg, alt. 1220 m., Sept., 1903, *Pegler 950* (AL); Zeerust, alt. 1220 m., Dec. 1927, *Thode* (DUR).

Bechuanaland Protectorate: Lobatsi, alt. 1189.5 m., Oct. 1913, *Rogers 6225* (AL, NAT); Mochudi, April, 1914, *Rogers 6900* (DUR).

6. **M. pulchella** Markgraf in Notizbl. 8: 219. 1922.

A dwarf, decumbent, suffruticose perennial, 0.4–0.8 dm. high; stems numerous, slender, angled, reddish-tinged, sparsely scaberulent on the margins of the decurrent petioles; leaves opposite, numerous, crowded, shortly petiolate, including the petiole, 6–9 mm. long, 3–6 mm. broad, minutely hirtellous on the margins, subcoriaceous, bi–tri-lobed, lobes oblong to obovate, 1.5–3 mm. long, 1–2.5 mm. broad, obtuse; flowers relatively few; pedicels solitary, terminal, 2–4 mm. long, glabrous, recurved in fruit; calyx campanulate, 5–6 mm. long; calyx-tube 2–3 mm. long, in anthesis 2 mm. broad, in fruit 3–4 mm. broad, glabrous; lobes 6–7, linear, 3–4 mm. long, 0.3–0.7 mm. broad, entire, acutish, sparsely ciliate on the margins; corolla subrotate to shortly infundibuliform, about 14 mm. long, golden-yellow to reddish, corolla-tube about 6 mm. long, 3 mm. broad at the orifice, sparsely pilose near the base of the throat within; lobes 5, broadly oblong, obtuse, about 8–10 mm. long, 4–5 mm. broad; stamens slightly exserted, about 7 mm. long; filaments glabrous, pollen regularly reticulate, 62.5–70.0 (75.0) μ in diameter; pistil 7–10 mm. long; ovules 4 in each cell; stigma small; capsule 3–4 mm. long, 5–6 mm. broad; seeds 4 in each cell (mature seeds not seen).

Distribution: southern Bolivia.

Specimens examined:

South America:

Bolivia: Condorhuassu bei Tarija, 3200 m., Feb. 6, 1904, *Fiebrig 2984* (F cotype).

7. M. integrifolia (Cham. & Schlecht.) Steud. Nom. Bot. ed. 2, **2**: 124. 1841; A. Gray in Am. Jour. Sci. II. **14**: 43. 1852; Walp. Ann. Bot. **5**: 487. 1858; Eichler in Mart. Fl. Bras. **6**^{1}: 318. *pl. 85. fig. 1.* 1868; Griseb. Symb. 224. 1879; Knobl. in Engler & Prantl, Nat. Pflanzenf. **4**^{2}: 14. 1895; Arechavaleta in Anal. Mus. Nac. Montevideo **7**: 61. 1909; Hicken, Chlor. Plat. Argent. 183. 1910.

Bolivaria integrifolia Cham. & Schlecht. in Linnaea **1**: 268. *pl. 4. fig. 1.* 1826; Hook. & Arn. in Hooker's Jour. Bot. **1**: 284. 1834; G. Don, Gen. Hist. Dichl. Pl. **4**: 58. 1838; Griseb. Gen. et Sp. Gentian. 20. 1839; A. DC. in DC. Prodr. **8**: 315. 1844.

Calyptrospermum integrifolium A. Dietr. in Linnaeus, Sp. Pl. [A. Dietrich] ed. 6. **1**: 227. 1831.

An erect, mostly unbranched, nearly herbaceous perennial, 2.7–4 dm. high; stems relatively few, simple, elongated, slender, angled, subherbaceous above, slightly branched and opposite at the base, glabrous; leaves opposite, rather numerous, linear, slightly petiolate, linear to linear-lanceolate, including the petiole, 10–32 mm. long, 1–3 mm. broad, submembranaceous, acute, mucronate, glabrous, mostly entire or bi–tri-fid; flowers usually numerous, in paniculate dichasial cymes; pedicels slender, 3–12 mm. long, glabrous, erect in fruit; calyx narrowly campanulate, 4–8 mm. long, glabrous or nearly so; calyx-tube 2–3 mm. long, in anthesis 1.5–2 mm. broad, in fruit about 3 mm. broad; lobes usually 5–6(–7), linear to linear-lanceolate, acute to acuminate, entire, rather bifid at the apex, 2.5–6 mm. long, 0.3–0.8 mm. broad, mostly glabrous; corolla shortly infundibuliform, 10–12 mm. long, corolla-tube about 4 mm. long, 2.5–3 mm. broad at the orifice, sparsely pilose at the base of the filaments within; lobes 5, narrowly elliptic-oblong, obtuse, 6–7 mm. long, 2.5–3 mm. broad; stamens slightly exserted, about 8 mm. long; filaments glabrous, connective prolonged at the apex into a short, cylindrical, blunt,

knob-like protuberance; pollen grain finely and regularly reticulate, (58.75); 75–87.5; (93.75) μ in diameter; pistil about 9 mm. long; ovules 4 in each cell; stigma capitate; capsule about 5 mm. long, twice as broad; seeds 4 in each cell, coarsely and regularly reticulate, 4–5 mm. long, 3 mm. broad.

Distribution: southern Bolivia to Paraguay, and south to Uruguay.

Specimens examined:

South America:

Bolivia: Sierra de La Cruz, alt. 2000 m., 1892, *Kuntze* (F, NY).

Paraguay: in the Camp Bord. de v. Rias, Dec. 4, 1928, *Jörgensen 4045* (M).

Uruguay [Brasilio meridionalis]: *Sellow* (C cotype).

7a. Var. **trifida** (Cham. & Schlecht.) Steyermark, n. comb.
Pl. 7, fig. 1.

Menodora trifida (Cham. & Schlecht.) Steud. Nom. Bot. ed. 2. **2**: 124. 1841; A. Gray in Am. Jour. Sci. II. **14**: 43. 1852; Walp. Ann. Bot. **5**: 487. 1858; Eichler in Mart. Fl. Bras. **6**^{1}: 318. *pl. 35. fig. 2.* 1868; Knobl. in Engler & Prantl, Nat. Pflanzenf. **4**^{2}: 14. 1895; Chodat in Bull. Herb. Boiss. II. **3**: 915. 1903; Macloskie in Rept. Princeton Univ. Exp. to Patagonia (Bot.) **8**^{2}: 658. 1905; Hicken, Chlor. Plat. Argent. 183. 1910.

Bolivaria trifida Cham. & Schlecht. in Linnaea **1**: 209. 1826; Graham in Edinb. New Phil. Jour. **10**: 167. 1830–31; G. Don, Gen. Hist. Dichl. Pl. **4**: 58. 1838; Griseb. Gen. et Sp. Gentian. 20. 1839; A. DC. in DC. Prodr. **8**: 315. 1844.

Calyptrospermum trifidum (Cham. & Schlecht.) A. Dietr. in Linn. Sp. Pl. [A. Dietr.] ed. 6. **1**: 226. 1831.

A diffusely spreading or decumbent, branching, subherbaceous perennial, 0.6–2.5 dm. high; stems glabrous to sparsely puberulent; leaves linear to oblanceolate, including the petiole, 3–22 mm. long, 0.5–11 mm. broad, mostly glabrous, entire to bi- to multi-lobed or cleft, lobes linear to oblong-lanceolate, 1.5–10 mm. long, 0.3–3 mm. broad, acute, mucronate; flowers solitary, terminal, in remotely flowered dichasial cymes; pedicels glabrous to sparsely puberulent; corolla 8–13 mm. long; corolla-tube 4–5 mm. long, 3.5–4 mm. broad at the orifice; pollen grain (62.50); 66.25–75.0; (81.25) μ in diameter.

In other respects similar to the species.

Distribution: central Bolivia and northern Paraguay south to Central Argentina.

Specimens examined:

South America:

Bolivia: Bolivian plateau, 1891, *Bang 942* (F, G, M, NY, P, US); Padcaya, alt. 2000–2100 m., Dec. 12, 1903, *Fiebrig 2530* (F, M), and *2531* (M); Cerrito, Ciudad Cochabamba, alt. 2600 m., Dec. 13, 1928, *Steinbach 8761* (M).

Paraguay: between Rio Apa and Rio Aquidaban, Dec. 3, 1908, *Fiebrig 4368* (G); Paraguay, Feb. 20–25, 1903, *Fiebrig 908* (F, G, US); in regione collium, Cerros de Paraguay, Dec. 1900, *Hassler 6475* (G); in Campa Tacuaral, Oct. 1885–95, *Hassler 1281* (NY).

Argentina: Cordoba, Dec., 1891, *Kuntze* (F, NY); Sierra de San Luis, Jan. 19–Feb. 19, 1895, *Kurtz 8456* (NY); Cordoba, Jan. 25, *Lossen 305* (G).

Uruguay: Tacuarembo, March, 1913, *Osten 6625b* (G).

8. M. Hassleriana Chodat in Bull. Herb. Boiss. II. **3**: 915. 1903.

A diffuse and decumbent to erect, subherbaceous perennial, 0.9–2 dm. high; stems numerous, slender, slightly angled, sparsely puberulent; leaves opposite to alternate, slightly petiolate, numerous, crowded, submembranaceous, elliptic-oblong to spatulate, obtuse, slightly mucronate, entire or 3–7-cleft or lobed, including the petiole, 5–20 mm. long, 2–12 mm. broad, the segments linear-lanceolate to spatulate, 3–8 mm. long, 1–3 mm. broad, glabrous; flowers relatively few; pedicels solitary, terminal, slender, 3–8 mm. long, scaberulent, erect in fruit; calyx campanulate, 5–8 mm. long; calyx-tube 2–2.5 mm. long, in anthesis 1–1.5 mm. broad, in fruit 2–2.5 mm. broad, glabrous or sparsely scaberulent; lobes 5–6, linear-lanceolate to linear-spatulate, obtuse or acutish, entire, 3–5 mm. long, about 1 mm. broad, glabrous; corolla infundibuliform, 7–8 mm. long, yellow; corolla-tube somewhat elongated, 2.5–3 mm. long, about 3 mm. broad at the orifice, sparsely pilose at the orifice within; lobes 5, elliptic-oblong, about 5 mm. long, about 2 mm. broad, obtuse; stamens slightly exserted, 5–6 mm. long; filaments glabrous, connective slightly prolonged at the

apex into a short cylindrical protuberance; pistil about 6 mm. long; ovules 4 in each cell; stigma capitate; capsule 5–6 mm. long, 10–11 mm. broad; seeds 4 in each cell, 5–5.5 mm. long, about 3 mm. broad, rather coarsely and regularly reticulated.

Distribution: Paraguay to central Argentina.

Specimens examined:

South America:

Paraguay: in campo humido in regione cursus superioris fluminis Apa, Dec. 1901–2, *Hassler 8278* (DC. herb. at Geneva, photograph, type).

Argentina: clay lowlands, General Roca and vicinity, Rio Negro Valley, alt. 250–360 m., Dec. 29, 1914, *Fischer 221* (US); vicinity of General Roca, Rio Negro, alt. 250–360 m., Sept. 1914–Feb. 1915, *Fischer 221* (F, G, M); en las lomas, Prov. de Tucuman, El Puestito, alt. 750 m., Nov. 14, 1928, *Venturi 7534* (G).

9. M. pinnatisecta Steyermark, n. sp.[39] Pl. 8, fig. 1.

An erect, nearly herbaceous perennial, 1–2 dm. high; stems fairly numerous, simple and somewhat elongated, slender, mostly terete, glabrous or rarely sparse-puberulent on the margins of the decurrent petioles; leaves opposite, numerous, crowded, shortly

[39] **M. pinnatisecta** Steyermark, sp. nov., erecta, subherbacea perennis, 1–2 dm. alta; caulibus plus minusve numerosis, simplicibus et subelongatis, angustis, teretibus plerumque, glabris vel infrequenter paulo puberulis; foliis oppositis, numerosis, congestis, breve petiolatis, anguste linearibus vel lineari-lanceolatis, petiolis includentibus, 4–20 mm. longis, alte pinnatisectis vel supremis integris, subcoriaceis, distincte cum nervo albo et margine albo, glabris, laciniis anguste linearibus vel lineari-lanceolatis, 3–13 mm. longis, 0.5–1.8 mm. latis, acutis vel acuminatis; floribus numerosis, cymis dichasialis subcorymbosis; pedicellis circiter 5 mm. longis, glabris, erectis in fructu; calyce anguste campanulato, 5–8 mm. longo, glabro vel sparse puberulo, calycis tubo 2.5–3 mm. longo, in florescente circiter 1.5 mm. lato, in fructu circiter 3.5 mm. lato; lobis 7–12, anguste linearibus, acutis vel acuminatis, integris, 3.5–6 mm. longis, 0.3–0.6 mm. latis; corolla subrotata, 7.5–10 mm. longa; corollae tubo brevi, 3 mm. longo, circiter 2 mm. lato orificio, ad apicem intra piloso; lobis 5–6, anguste elliptico-oblongis vel elliptico-lanceolatis, plus minusve acutis, mucronatis, 5–6 mm. longis, 1.75–2 mm. latis; staminibus paulo exsertis, circiter 6 mm. longis; filamentis glabris, connectivo elongato apice in protuberans relative longum cylindratum; polline plus minusve minute et regulariter reticulato (62.50); 68.75–81.25; (100.0) μ in diametro; pistillo circiter 7 mm. longo; ovulis 4 in quaque cella; stigmate capitato; capsula 5–6 mm. longa, circiter 10 mm. lata; seminibus 4 in quaque cella, rugose et regulari reticulato, 4–5 mm. longis, 3 mm. latis.—type collected on el campo, Las Palmas, Territorio del Chaco, Argentina, Nov. 9, 1917, *Jörgensen 2643* (G).

petiolate, narrowly linear to linear-lanceolate, including the petiole, 4–20 mm. long, deeply pinnatisect or the uppermost entire, subcoriaceous, conspicuously white-nerved and white-margined, glabrous, the segments narrowly linear to linear-lanceolate, 3–13 mm. long, 0.5–1.8 mm. broad, acute to acuminate; flowers numerous, in dichasial subcorymbose cymes; pedicels about 5 mm. long, glabrous, erect in fruit; calyx narrowly campanulate, 5–8 mm. long, glabrous to sparsely puberulent; calyx-tube 2.5–3 mm. long, in anthesis about 1.5 mm. broad, in fruit about 3.5 mm. broad; lobes 7–12, narrowly linear, acute to acuminate, entire, 3.5–6 mm. long, 0.3–0.6 mm. broad; corolla subrotate, 7.5–10 mm. long; corolla-tube short, 3 mm. long, about 2 mm. broad at the orifice, pilose at the orifice within; lobes 5–6, narrowly elliptic-oblong to elliptic lanceolate, more or less acute, mucronate, 5–6 mm. long, 1.75–2 mm. broad; stamens slightly exserted, about 6 mm. long; filaments glabrous, connective prolonged at the apex into a relatively long, cylindrical protuberance; pollen grain finely and regularly reticulate, (62.50); 68.75–81.25; (100.0) μ in diameter; pistil about 7 mm. long; ovules 4 in each cell; stigma capitate; capsule 5–6 mm. long, about 10 mm. broad; seeds 4 in each cell, coarsely and irregularly reticulate, 4–5 mm. long, 3 mm. broad.

Distribution: northeastern Argentina.

In its 7–12 calyx-lobes and deeply pinnatisect leaves this species differs from its closest affinities, *M. integrifolia* var. *trifida* and *M. Hassleriana*. From the former it also differs in its more or less erect strict habit, and from the latter in its acute to acuminate leaf segments.

Specimens examined:

South America:

Argentina: common on el campa, Las Palmas, Territorio del Chaco, Nov. 9, 1917, *Jörgensen 2643* (G type).

10. M. scabra (Engelm.) A. Gray in Am. Jour. Sci. II. **14**: 44. 1852; Torrey in Pacif. R.R. Rept. **7**: 18. *pl. 7.* 1857; Walp. Ann. Bot. **5**: 487. 1858; A. Gray, Syn. Fl. N. Am. **2**[1]: 78. 1878; Rothrock in Rept. Wheeler Exp. 185. 1878; Hemsl. Biol. Cent.-Am. Bot. **2**: 384. 1881, and **4**: 67. 1886; Watson in Proc. Am. Acad. **18**:

112. 1883; Coulter in Contr. U. S. Nat. Herb. **2**: 261. 1892; Knobl. in Engler & Prantl, Nat. Pflanzenf. 4[2]: 14. *fig. 8.* 1895; Small, Fl. S. E. U. S. ed. 1. 916. 1903, and ed. 2. 917. 1913; Wooton & Standley in Contr. U. S. Nat. Herb. **19**: 497. 1915; Rydb. Fl. Rocky Mts. 656. 1917, and ed. 2. 656. 1922; Standl. in Contr. U. S. Nat. Herb. **23**: 1138. 1924; Tidestrom in Contr. U. S. Nat. Herb. **25**: 413. 1925; Jepson, Man. Fl. Pl. Calif. 761. 1925. Pl. 4. figs. 13–14; pl. 7, fig. 2.

Bolivaria scabra Engelm. mss.

A nearly herbaceous, erect perennial, 0.7–3.5 dm. high, simulating species of *Linum* in appearance; stems numerous, slender, strict, mostly terete, clustered below, simple and elongated above, sparsely to moderately scaberulent or rarely glabrous, internodes short; leaves opposite or alternate, numerous, crowded, sessile, foliose throughout, linear to linear-lanceolate, the lowest mostly oblong-lanceolate to obovate, 8–38 mm. long, 1–4 mm. broad, entire, acute, subcoriaceous, sparsely hirtellous, especially on the margins and midrib; flowers very numerous, in dichasial to pleiochasial subcorymbose cymes; pedicels slender, 3–20 mm. long, sparsely scaberulent, erect in fruit; calyx campanulate, 4–9 mm. long, somewhat scaberulent; calyx-tube 1.5–3 mm. long, in anthesis 1.5–3 mm. broad, in fruit 3–5 mm. broad; lobes 7–12, equal or unequal, linear to linear-spatulate, entire, acute to slightly obtuse, 3–7 mm. long, 0.2–0.8 mm. broad, slightly roughened; corolla subrotate, 9–12 mm. long, bright yellow, corolla-tube short, 3–4 mm. long, 2–3 mm. broad at the orifice, pilose at the orifice within; lobes 5, oblong to obovate, obtuse, slightly mucronate, 5–8 mm. long, 3–5 mm. broad, glabrous or sparsely pilose without; stamens exserted, 6–8 mm. long; filaments glabrous, connective prolonged into a short rounded protuberance; pollen grain finely and regularly reticulate, 62.5–87.5; (100.6) μ in diameter; pistil usually 8–9 mm. (rarely 10–11 mm.) long; ovules 4 in each cell; stigma capitate; capsule 5–7 mm. long, 7–12 mm. broad; seeds 4 in each cell, scrobiculate (with small, narrow, deeper irregular pits), seeming smooth to the naked eye, 5–6 mm. long, 4 mm. broad.

Distribution: southern Colorado, Utah and Lower California, south to Durango, Mexico.

Specimens examined:

United States:

Texas: El Paso, Aug. 4, 1920, *Schulz 221* (NY).

Colorado: gravelly adobe soil in Pinon forest, along foothills, road 10 mi. n. of Canon City, between Canon City and Colorado Springs, July 3, 1921, *Bethel* (G); dry soil, open woods, east of Canon City, Fremont Co., alt. 1720 m., July 3, 1921, *Bethel, Willey & Clokey 4236* (F, M, NY, P, POM, US); Pueblo Co., Oct. 20, 1873, *Greene 8* (F); Betio, Canon City and Colorado Springs, June 30, 1927, *Osterhout 6840* (NY, POM).

New Mexico: Pecos, alt. 2100 m., June 18, 1927, *Arsène 18616* (POM); La Glorieta, Sept. 1879, *T. S. Brandegee 11936* (M); Nutt, Sept. 3, 1903, *Diehl 750* (POM); Santa Fe, July 20, 1898, *Earle 74* (M, NY); wash near Paddy's hole, Catron Co., July 28, 1924, *Eggleston 20354* (NY); Sandia Mts., 1914, *Ellis 372* (US); open flats, eastern slope Las Palomas, Sandia Mts., alt. 2135 m., June 18, 1914, *Ellis 372* (NY, US); arid hills near Santa Fe, Sept. 8, 1881, *Engelmann* (M); 1847, *Fendler 693* (C, F, G, M, NY, P, US); Albuquerque, *Harward* (M); Santa Fe, alt. 2195 m., July 8, 1897, *A. A. Heller & E. G. Heller 3826* (G, M, NY, POM, US); Monument No. 40, Mexican boundary line, May 9, 1892, *Mearns 252* (US); Pinus Altus, Aug. 9, 1895, *Mulford 807* (US); Pinus Altus, Aug. 7, 1895, *Mulford 805* (NY); between Anton Chico and Las Vegas, Oct. 1, 1913, *Rose & Fitch 17653* (NY, US); Santa Fe, June, 1874, *Rothrock 60* (F, P); plains, near Ft. Wingate, July, 1880, *Rusby 255* (C, F, M, NY, US); 1881, *Rusby* (NY); cedar slopes, near Queen, Aug. 12–20, 1924, *Standley 40689* (US); dry hillside near Carlsbad Cavern, Aug. 12–20, 1924, *Standley 40400* (US); dry field, Black River, Eddy Co., Aug. 12–20, 1924, *Standley 40455* (US); dry rocky slope, near Sitting Bull Falls, Guadalupe Mts., Aug. 12–20, 1924, *Standley 40729* (US); near Pecos, San Miguel Co., alt. 2042 m., Aug. 15, 1908, *Standley 4967* (G, M, NY, US); *Thurber 693* (G); n. hillside, High Rolls and vicinity, Otero Co., alt. 1830 m., May 21–28, 1902, *Viereck 500251* (P); Ojo del Muerto, south of Santa Fe, Aug. 2, 1846, *Wislizenus 68* (M type); 5 mi. west of Silver City, July 4, 1906, *Wooton* (US); 1851–52, *Wright 1694* (US).

Arizona: rim, Grand Canyon, July 6, 1912, *Condit* (C); Duncan

Plains, Oct. 1, 1900, *Davidson 444a* (G); Blue River, Sept. 10, 1902, *Davidson 756* (POM); moist cañon, July 21, 1896, *Fernow* (US); semi-meadow, 12 miles n. of White River, White Mts., alt. 1616.5 m., June 23, 1930, *Goodman & Hitchcock 1302* (M); Ash Fork, June 20, 1903, *Griffiths 4767* (US); Prescott, July 8–25, 1903, *Griffiths 4882* (US); White Mts., Aug. 6–15, 1903, *Griffiths 5389* (US); along road to Hopi Point, Grand Canyon, alt. 1500–2100 m., July 1, 1913, *Hitchcock 104* (US); Ft. Apache, July 10, 1901, *M. Z. Hough* (F); Chalcedony Park, July, 1897, *W. Hough 34* (G, M, US); Phoenix, alt. 350 m., May 6, 1903, *M. E. Jones* (POM); Clemenceau, May 25, 1922, *W. W. Jones* (M); Cedar Glade, June 16, 1922, *W. W. Jones* (M); near Flagstaff, alt. 610 m., June 23, 1901, *Leiberg 5555* (US); Santa Catalina Mts., May, 1881, *Lemmon 164* (C); Ft. Lowell, *Lemmon* (C); in the vicinity of Flagstaff, alt. 2133 m., July 4, 1898, *MacDougal 218* (C, F, G, NY, P, US); Fort Apache, 1901, *Mayerhoff 105*, in part (F); 1869, *Ed. Palmer* (P, US); rocky soil, Flagstaff, May–Oct., 1900, *Purpus 8057* (C, M, POM, US); Peach Springs, July 6, 1883, *Rusby 718* (M); 10 mi. s. of Grand Canyon, July 13, 1892, *Wooton* (US); Holbrook, Aug. 17, 1896, *Zuck* (US); Prescott, July 29, 1896, *Zuck* (NY).

UTAH: southern Utah, 1877, *Ed. Palmer 65* (G, M, NY, US); rocky soil, Cane Spring Mts., alt. 1220–1525 m., May–Oct., 1898, *Purpus 6228* (C, NY, US).

MEXICO:

LOWER CALIFORNIA: July 4, 1884, *Orcutt* (US); Cantillas Mts., July, 1884, *Orcutt* (US); Japa, July 25, 1883, *Orcutt 926* (C); Parry's Pinesap, April 7, 1884, *Orcutt* (C, F).

CHIHUAHUA: Ojo de Vaca, etc., June, 1851, *Thurber 318* (F, G); Copper Mines, July, 1851, *Thurber 232* (G, NY).

DURANGO: Tepehuanes, June 4–25, 1906, *Ed. Palmer 309* (C, F, NY, US).

10a. Var. **laevis** (Wooton & Standley) Steyermark, n. comb.

M. laevis Wooton & Standley in Contr. U. S. Nat. Herb. [Fl. N. Mex.] **16**: 158. 1913, and **19**: 497. 1915.

Leaves, including the petiole, 2–17 mm. long, 1–5 mm. broad, obtuse or acute, distinctly mucronate, glabrous or sparsely

scaberulent, the lower and middle ones ovate or elliptic-oblong to oblong-lanceolate, the upper ones becoming lanceolate; pedicels glabrous to moderately scaberulent; calyx glabrous to slightly roughened; corolla 11–14 mm. long; corolla-tube almost entirely glabrous within except for the few slender hairs around the insertion of the filament on the tube; lobes elliptic-obovate to subovate, acute to acuminate, distinctly mucronate; connective of the anther prolonged at the apex into a short subcuneate protuberance; seeds 4–5 mm. long, 3–3.5 mm. broad.

Distribution: southwestern Texas, west to southeastern California and Mexico.

Specimens examined:

United States:

Texas: semi-desert, mountain sides, Franklin Mts., near El Paso, Altura Park, El Paso Co., July 10, 1911, *Barlow* (F); Mesa, El Paso, May 8–19, 1902, *Earle 482* (NY); common and abundant, rocky slopes and along dry creek beds, Redford, Aug. 7, 1919, *Hanson 791* (US); common and abundant along arroyos and slopes, Redford, Aug. 7, 1919, *Hanson 791* (G); El Paso, June 4, 1895, *Mulford 251* (M, NY); near Medira Creek, Presidio Co., Sept., 1892, *Nealley 159a* (US); Langtry, Valverde Co., May, 1913, *Orcutt 6131* (POM); rocky banks, along Blue Creek, near Trap Mountain, Chisos Mountains, Brewster Co., May 26, 1928, *E. J. Palmer 34191* (M type); El Paso, Aug. 1920, *Schulz 247* (POM); El Paso, Aug. 4, 1920, *Schulz 221* (NY); vicinity of El Paso, Sept., 1911, *Stearns* (US); mesas, vicinity of El Paso, 1911, *Stearns 66* (US); vicinity of El Paso, 1911, *Stearns* (NY); hills bordering salt basin, west of Kent, Aug. 6, 1916, *Young* (M).

New Mexico: Socorro, July 14, 1897, *Herrick* (US); Socorro, July 14, 1897, *Herrick 708* (US); Rincon, Sept. 9, 1884, *M. E. Jones 4167* (F, NY, US); Cedar Spring, Aug. 27, 1895, *Mulford 1073* (US); Mexican Boundary Survey, *Parry, Bigelow & Schott* (NY); Organ Mts., 1881, *Vasey* (F, G, US type of *M. laevis*); 1881, *Vasey* (NY); Monument No. 6 to Monument No. 12, Sept. 20–24, 1892, International Boundary Commission U. S. & Mexico, *Wagner 956* (US); Organ Mountains, Dona Ana Co., alt. 1433.5 m., July 15, 1897, *Wooton 154* (C, G, M, POM, US); La Luz Canyon, Sacramento Mts., Aug. 27, 1901, *Wooton* (US); on the

mesa west of the Organ Mountains, Little Mt., Dona Ana Co., Aug. 29, 1903, *Wooton* (M); on the mesa west of the Organ Mts., Dona Ana Co., Aug. 29, 1902, *Wooton* (C, POM); in the Organ Mts., Dona Ana Co., alt. 1677.5 m., Sept. 23, 1906, *Wooton & Standley* (US); 1851–52, *Wright 1694* (NY, US).

ARIZONA: eight mi. s. of Vail, alt. 1220 m., Aug. 31, 1903, *M. E. Jones* (POM); mesas, Tucson, alt. 732 m., May 22, 1903, *Thornber 448* (C, M, NY, POM, US); mesas, Tucson, Aug. 27, 1901, *Thornber* (C).

CALIFORNIA: Barnwell, May, 1911, *K. Brandegee* (C).

MEXICO:

CHIHUAHUA: hills near Chihuahua, Aug. 9, 1885, *Pringle 549* (G); abundant on mesas, Oct. 1911, *Stearns 66* (F, G).

10b. Var. **ramosissima** Steyermark, n. var.[40]

A paniculately branched, erect, suffruticose perennial, 3–9 dm. high, not simulating species of *Linum* in appearance; stems much branched, but not clustered below; internodes elongated, petiolate below, subsessile above, elliptic-oblong to sublanceolate, including the petiole, 5–40 mm. long, 1–9 mm. broad, submembranaceous, distinctly mucronate, glabrous to sparsely scaberulent; flowers in loose pleiochasial paniculate to subcorymbose cymes; calyx glabrous to densely scaberulent; corolla-tube 4.5–5 mm. long; corolla-lobe 4.5–6 mm. long; stamens 9–10 mm. long; connective prolonged at the apex into a short, cylindrical, blunt protuberance; pistil 10–11 mm. long; seeds coarsely reticulate with the deeper irregular pits appearing on the surface more frequently than in the species, 4.5–5 mm. long, about 3 mm. broad.

Distribution: western Texas to central Arizona and northern Mexico.

[40] Var. **ramosissima** Steyermark, var. nov., paniculate ramosa, erecta, suffruticosa perennis, 3–9 dm. alta, non simulans speciebus Lini habitu; caulibus multo ramosis, sed non congestis infra; internodiis elongatis, inferioribus petiolatis, superioribus subsessilibus, elliptico-oblongis, 5–40 mm. longis, 1–9 mm. latis, submembranaceis, distincte mucronatis, glabris vel sparse scaberulentis; floribus pleiochasialis paniculatis vel subcorymbosis in cymis; corollae tubo 4.5–5 mm. longo; corollae lobis 4.5–6 mm. longis; staminibus 9–10 mm. longis, connectivo elongato apice in protuberans breve cylindratum; pistillo 10–11 mm. longo; seminibus reticulatis cum plus rugositate, cum cavibus altioribus occurrentibus plus frequenter in integumento exteriore quam in specie, 4.5–5 mm. longis, circiter 3 mm. latis.—TYPE collected near El Paso, El Paso Co., Texas, June 19, 1926, *E. J. Palmer 31083* (M).

Specimens examined:

United States:

Texas: El Paso, Sept. 22, 1901, *Bailey 748* (US); common in gulches, eastern slope Franklin Mts., El Paso Co., June 29, 1921, *Ferris & Duncan* (M, NY); El Paso, July 17, 1922, *Fisher 319* (NY); Chenates region, 1889, *Nealley 471* (F, US); dry rocky ground, near El Paso, El Paso Co., June 19, 1926, *E. J. Palmer 31083* (M type); Franklin Mts., El Paso Co., Sept. 1915, *Slater* (US); gravelly mesa, west side of Chisos Mts., Brewster Co., June 27, 1931, *Moore & Steyermark 3256* (G, M, NY); western Texas, *Wright* (P); foothills of Chenate Mts., Sept. 9, 1914, *Young 54* (M); foothills of Chenate Mts., Sept. 8, 1914, *Young 11* (M); foothills of Chenate Mts., Sept. 9, 1914, *Young* (M).

New Mexico: on hillsides, Lake Valley, Sept. 1914, *Beals* (US); Mexican Boundary Survey, in the valley of Rio Grande, below Donana, *Bigelow* (NY); Albuquerque, Sept. 4, 1894, *Herrick* (NY); Rincon, Sept. 9, 1884, *M. E. Jones 4167* (POM); near mouth dry cañon in arroyo, Alamogordo, Otero Co., alt. 1403 m., April 7–May 24, 1902, *Rehn & Viereck 500249* (P); to arroyo base foothills, Alamogordo, Otero Co., alt. 1326.75 m., April 7–May 24, 1902, *Rehn & Viereck 500250* (P); Tortugas Mts., e. of Mesilla Park, July 15, 1906, *Standley 545* (M); Monument No. 6 to Monument No. 12, Sept. 20–24, 1892, International Boundary Commission U. S. & Mexico, *Wagner 956* (US); Little Mt., near Las Cruces, alt. 1220 m., Sept. 2, 1894, *Wooton* (NY); Organ Mts., Dona Ana Co., alt. 1433.5 m., July 15, 1897, *Wooton 154* (NY); on the mesa west of the Organ Mts., Tortugas Mts., Dona Ana Co., alt. 1281 m., Sept. 1, 1908, *Wooton & Standley* (US); on the mesa west of the Organ Mts., Tortugas Mts., Dona Ana Co., alt. 1403 m., Aug. 19, 1906, *Wooton & Standley* (US); on the mesa west of the White Mts., Tortugas Mt., Lincoln Co., July, 1906, *Wooton & Standley* (US); May–Oct. 1849, *Wright 563* (F, G, NY, US); 1851–52, *Wright 1694* (F, G, NY).

Arizona: Roosevelt Dam, May 17, 1919, *Eastwood 8671* (G, US); buttes, Tempe, April 21, 1892, *Ganong & Blaschka* (G); on "prairie," N. Fifth Ave., vicinity of Tucson, April 29, 1913, *J. M. & M. T. Greenman 4a* (M); Tucson Mountain, vicinity of Tucson, alt. 762.5 m., April 11, 1913, *J. M. & M. T. Greenman 4*

(M); on trip to Tucson Mt., March 7, 1901, *Griffiths 2436* (NY); Ft. Apache, 1893, *Hoyt* (NY); Tucson, alt. 701.5 m., Aug. 17, 1903, *M. E. Jones* (POM); Congress Junction, alt. 915 m., May 1, 1903, *M. E. Jones* (M, POM, US); Papago Reservation, May 7, 1930, *M. E. Jones 26448* (M); desert, Phoenix, May 18, 1897, *Kunze* (NY); Santa Catalina Mts., May, 1881, *Lemmon 164* (C); Sierritas Mts., west of Tucson, April, 1881, *Lemmon 164* (G); Dutch Charley's Ranch, near Monument No. 88, Mexican Boundary Survey, Aug. 13, 1893, *Mearns 1868* (NY, US); Camp Grant, May 4, 1867, *Ed. Palmer 206* (G); on the mesas at Camp Grant, May 4, 1867, *Ed. Palmer 206* (M); Lowell and Tucson, April–May, 1884, *W. F. Parish 142* (F); Nogales, Aug. 28, 1927, *Peebles & Harrison 4725* (US); hills near Tucson, April 27, May 17, 1883, *Pringle* (F, G, NY, P, US); hills near Tucson, May, 1883, *Pringle 15602* (M); Bradshaw Mt., alt. 2836.5 m., April–Sept., 1903, *Purpus* (C); Desert Botanical Laboratory, Tucson, 1905, *Rose 44* (US); laboratory hill, in vicinity of Tucson, April 27, 1910, *Rose, Standley & Russell 15188* (US); Sienega, alt. 1183.4 m., Aug., 1874, *Rothrock 561* (F, G, US); Tumamoc Hill, alt. 793 m., Aug., 1916, *Shreve 4896* (AR); Tucson, Tumamoc Hill, alt. 793 m., Sept. 20, 1916, *Shreve 4988* (C); Tucson, May 15, 1892, *Toumey 206a* (US); Copper town?, Aug. 25, 1894, *Toumey* (NY); Holbrook, Aug. 17, 1896, *Zuck* (US).

MEXICO:

NUEVO LEON: Monterey, *Eaton & Edwards* (NY).

CHIHUAHUA: Sabinal, Sierra Madre Mts., alt. 1281 m., Sept. 29, 1903, *M. E. Jones* (POM); between Casas Grandes and Sabinal, Sept. 4–5, 1899, *Nelson 6362* (US); common on mesas, Oct. 1911, *Stearns* (F); Santa Eulalia hills, Aug. 8, 1885, *E. Wilkinson* (C); St. Eulalia Mts., May 29, 1885, *Wilkinson* (F, US).

10c. Var. **longituba** Steyermark, n. var.[41]

Internodes elongated; leaves not crowded, mostly remote,

[41] Var. **longituba** Steyermark, var. nov., internodiis elongatis; foliis non congestis, plerumque remotis oblanceolatis vel lanceolatis, 1.5–7 mm. latis, submembranaceis, glabris; floribus in laxis paniculatis cymis; corolla infundibuliforme, 15–17 mm. longa, corollae tubo relative elongato, 6–7 mm. longo, 4–4.5 mm. lato orificio; lobis 9–10 mm. longis, 5–6 mm. latis, distincte mucronatis, staminibus 10–12 mm. longis; pistillo 13–14 mm. longo.—TYPE collected in the Massatzal Mountains, May 5, 1867, *Smart 213* (G).

oblanceolate to lanceolate, 1.5–7 mm. broad, submembranaceous, glabrous; flowers in loose paniculate cymes; corolla infundibuliform, 15–17 mm. long, corolla-tube relatively elongated, 6–7 mm. long, 4–4.5 mm. broad at the orifice; lobes 9–10 mm. long, 5–6 mm. broad; stamens 10–12 mm. long; pistil 13–14 mm. long.

Distribution: central Arizona.

Specimens examined:

Arizona: Massatzal Mountains, May 5, 1867, *Smart 213* (G type).

11. M. decemfida (Gill.) A. Gray in Am. Jour. Sci. II. **14:** 44. 1852; Walp. Ann. Bot. **5:** 487. 1858; Hemsl. Biol. Cent.-Am. Bot. **2:** 304. 1881. Pl. 8, fig. 2.

Bolivaria decemfida Gill. ex Hook. & Arn. in Hook. Jour. Bot. **1:** 284. 1834; A. DC. in DC. Prodr. **8:** 315. 1844.

A small, erect, branching, suffruticose perennial, simulating *Spartium radiatum* in appearance; stems rather numerous, slender, strict, 4-angled, glabrous; leaves not crowded, opposite, sessile, linear-lanceolate, 5–15 mm. long, 1–2 mm. broad, entire, acute, glabrous, subcoriaceous; flowers numerous in dichasial cymes; pedicels slender, 3–5 mm. long, 0.5–0.8 mm. broad, glabrous; calyx campanulate, 5–7 mm. long, glabrous, calyx-tube 3–3.5 mm. long, about 2 mm. broad in anthesis; lobes entire, about 10, linear, 2–3 mm. long, about 0.2 mm. broad, acute to acuminate; corolla shortly infundibuliform, 13–16 mm. long, corolla-tube about 6 mm. long, about 3 mm. broad at the orifice, densely pilose within; lobes 5, narrowly oblong, obtusish or mucronate, 7–11 mm. long, 3–4 mm. broad; stamens exserted, 15–16 mm. long; filaments glabrous, connective slightly prolonged at the apex into a blunt, cylindrical protuberance; pollen grain finely and regularly reticulate, (56.25); 62.50–71.25 (76.25) μ in diameter; pistil 10–13 mm. long; ovules 4 in each cell; stigma capitate; capsule not seen.

Distribution: valleys of the Andes of Mendoza, central Chile.

The specimen cited is the only one so far encountered which agrees with the original description.

Specimens examined:

South America: with incomplete data, *Fielding* (G), "collector *Gillies* in Fielding Herbarium," according to I. M. Johnston.

11a. Var. **longifolia** Steyermark, n. var.[42]

Leaves, including the petiole, 6–40 mm. long, slightly mucronate; calyx 5–11 mm. long, calyx-tube 2–3 mm. long; lobes 8–11, 4–8 mm. long; corolla-tube 4–5 mm. long; corolla-lobes oblong to obovate, 10–12 mm. long, 5–8 mm. broad; stamens 11–12 mm. long.

Distribution: central Mexico and Texas.

This is here treated as a variety of the South American *M. decemfida*, which it resembles very closely. One might expect that the geographical distribution of a species and its variety would more nearly approach each other than is found in this case. However, notwithstanding the fact that, as far as present collections are concerned, the species and its variety are geographically widely separated, yet the close morphological relationships between the two seem to warrant the tentative treatment of the Texas and Mexican plant as a variety of the Chilean species.

Specimens examined:

UNITED STATES:

TEXAS: foothills of Chisos Mts., July, 1883, *Havard* (US); gravelly mesa, west side of Chisos Mts., Brewster Co., June 27, 1931, *Moore & Steyermark 3257* (C, M, NY).

MEXICO:

SAN LUIS POTOSI: 1879, *Schaffner 506* (F); Sept., 1876, *Schaffner 67* (G).

DURANGO: Santiago Papasquiara, April, Aug. 1896, *Ed. Palmer 429* (C, F, M TYPE, NY, US).

12. M. longiflora (Engelm.) A. Gray in Am. Jour. Sci. II. **14**: 45. 1852; Walp. Ann. Bot. **5**: 488. 1858; A. Gray, Syn. Fl. N. Am. **2**[1]: 78. 1878; Hemsl. Biol. Cent.-Am. Bot. **2**: 304. 1881, and **4**: 67. 1886; S. Watson in Proc. Am. Acad. **18**: 122. 1883; Coulter in Contr. U. S. Nat. Herb. **2**: 268. 1892; Knobl. in Engler & Prantl, Nat. Pflanzenf. **4**[2]: 14. 1895; Standl. in Contr. U. S. Nat. Herb. **23**: 1137. 1924. Pl. 4, fig. 4; pl. 9, fig. 1.

[42] Var. **longifolia** Steyermark, var. nov., foliis, petiolis includentibus, 6–40 mm. longis, submucronatis; calyce 5–11 mm. longo; calycis tubo 2–3 mm. longo; lobis 8–11, 4–8 mm. longis; corollae tubo 4–5 mm. longo; corollae lobis oblongis vel obovatis, 10–12 mm. longis, 5–8 mm. latis; staminibus 11–12 mm. longis.—TYPE collected at Santiago Papasquiara, state of Durango, Mexico, April, August, 1896, *Ed. Palmer 429* (M).

M. pubens A. Gray in Am. Jour. Sci. II. **14**: 45. 1852; A. Gray, Syn. Fl. N. Am. **2**[1]: 79. 1878; S. Watson in Proc. Am. Acad. **18**: 112. 1883; Coulter in Contr. U. S. Nat. Herb. **2**: 261. 1892; Knobl. in Engler & Prantl, Nat. Pflanzenf. **4**[2]: 14. 1895.

Menodoropsis longiflora (A. Gray) Small, Fl. S. E. U. S. ed. 1, 917. 1903, and ed. 2, 917. 1913.

Menodora hispida Palmer in Jour. Arnold Arb. **10**: 43. 1929.

Bolivaria longiflora Engelm. mss.

An erect, branching, nearly herbaceous perennial, 1–9 dm. high; stems very numerous, slender, almost simple, and much elongated, to paniculately branched and shortened, slightly angled, glabrous to densely hirsute-pilose; internodes short, leaves mostly opposite or the uppermost alternate, numerous, sessile to subpetiolate, linear to elliptic-lanceolate, or elliptic-oblong, 5–55 mm. long, 2–8 mm. broad, mostly entire, occasionally the lowest bi- or tri-lobed, obtuse to acute or mucronate, glabrous to somewhat hirsute-pilose, subcoriaceous; flowers numerous in terminal sub-corymbose cymes; pedicels slender, 5–22 mm. long, glabrous to moderately hirsute-pilose, erect in fruit; calyx campanulate to turbinate, 8–23 mm. long, glabrous to somewhat hirsute-pilose; calyx-tube 2–3 mm. long, in anthesis 2–3 mm. broad, in fruit 4–6 mm. broad; lobes 8–12, mostly 10, equal or unequal, linear, entire and rarely bifid, 8–18 mm. long, 0.2–1 mm. broad, glabrous to moderately hirsute; corolla hypercrateriform, 30–60 mm. long, bright yellow, corolla-tube 25–53 mm. long, 4–5 mm. broad at the orifice, entirely glabrous; lobes 5, ovate, acute, distinctly mucronate, 9–15 mm. long, 5–8 mm. broad; stamens included; filaments glabrous; pollen grain with more or less regular reticulation, (112.55); 125–143.75; (162.5) μ in diameter; pistil 25–50 mm. long; ovules 4 in each cell; stigma broadly capitate; capsule 8–10 mm. long, 10–17 mm. broad; seeds 4 in each cell, with large irregular reticulations, 5–7 mm. long, 4–5 mm. broad.

Distribution: western Texas and southern New Mexico south to the state of Puebla, Mexico.

The plant which E. J. Palmer recently described as a new species, namely, *M. hispida*, is in all respects like *M. longiflora*. The numerous and very elongated calyx-lobes and the large capsule place it at once with the latter species. Although Palmer

states at the end of his description, "flowers not seen," the writer nevertheless has found one or two flowers on the specimen which were badly aborted by insects. Because of this insect injury there are no fully developed flowers on the specimen, but the remains of the long, hypercrateriform corolla, which is characteristic of no other species except *M. longiflora*, is slightly indicated.

The writer has also found it necessary to treat Gray's *Menodora pubens* as synonymous with *M. longiflora*, since numerous specimens have been found which show intergradations in the degree of pubescence and breadth of the leaves. Gray describes *M. pubens* as "pubescent throughout with soft and spreading hairs: leaves rather broader: otherwise nearly resembling the preceding." Since so much intergradation occurs in the degree of pubescence and in the breadth of the leaves, and since no other morphological characters have been found which will distinguish the glabrous from the pubescent forms, it has been thought better to treat such examples under one species.

Specimens examined:

United States:

New Mexico: on ridge at head of Willow Seep Canyon, Guadalupe Mts., Lincoln (Alamo) Forest, alt. 2165 m., Sept. 14, 1916, *Chapline 485½* (NY); in the valley of the Rio Grande, below Donana, *Parry, Bigelow, Wright & Schott 1100* (NY); Queen, alt. 1799.5 m., Aug. 2, 1909, *Wooton* (US); vicinity of Queen, Eddy Co., Aug. 1, 1909, *Wooton* (US).

Texas: *Bigelow 80* (F); Glass Mts., Sept. 10, 1925, *Bogusch 984* (POM); *Buckley* (P); scattered, woodland, ridge 1 mi. s. of McCollaum's Ranch, Lincoln (Alamo) Forest, alt. 2135 m., Oct. 3, 1915, *Chapline 485* (G); rocks in canyon, North Van Horn, El Paso Co., July 8, 1900, *Eggert* (G, M); between Sonora and "Swayer Spring" at head of Llano River, Sutton Co., alt. 700 m., July 16, 1920, *Eggleston 16725* (US); chaparral slopes, Juniper Cañon, Chisos Mts., Brewster Co., alt. 1680 m., July 15–18, 1921, *Ferris & Duncan 2820* (M, NY); foothills of Chisos Mts., July, 1883, *Havard* (US); Kerrville, Kerr Co., alt. 488–610 m., June 12–19, 1894, *Heller 1880* (C, F, G, M, NY, POM, US); Kerrville, July, 1889, *Hopkins* (US); 1849–51, Pierdanales, *Lindheimer* (NY); upper Guadaloupe, June-July, 1847, *Lindheimer 652a* and *652b*

(M); on grassy, gravelly soil with *Dasylirion*, on the upper Guadaloupe, July, 1847, *Lindheimer 652* (F, G, M, US); Comanche Spring, New Braunfels, July, 1849, *Lindheimer 983* (F, G, M, NY, US); high plateaus on the upper Guadaloupe, sparsely on sterile gravelly soil, June, 1847, *Lindheimer 652* (M TYPE); on gravelly sterile soil, sparse, forming large bushes, with *Ruta*, *Dasylirion*, upper Guadaloupe, June–July, 1847, *Lindheimer 426* (G); Camp Charlotte, 1889, *Nealley 683*, and *684* (US); Camp Charlotte, 1889, *Nealley 294* (F); Chenates region, 1889, *Nealley 471a* (US); 1887, *Nealley* (US); western Texas, 1890, *Nealley* (F); dry rocky hillsides, Kerrville, Kerr Co., Oct. 2, 1916, *E. J. Palmer 10883* (M); dry limestone hills, Montell, Uvalde Co., Oct. 14, 1917, *E. J. Palmer 12976* (M); dry limestone hills, Montell, Uvalde Co., Oct. 15, 1917, *E. J. Palmer 12992* (M); rocky hillsides, Telegraph, Kimble Co., Oct. 8, 1916, *E. J. Palmer 10937* (M); rocky bluffs, Twin Mts., May 20, 1903, *Reverchon* (M); sandy soils, Sabinal, June, 1884, *Reverchon 1556* (M); rocky bluffs, Sabinal, Uvalde Co., June, 1885, *Reverchon 1556* (F, US); Rio Bravo del Norte, Springhills, Coalsprings, Aug. 1852, *Schott* (F); rocky grassy slope, upper Blue Creek, Chisos Mts., Brewster Co., June 25, 1931, *Moore & Steyermark 3242* (G, M, NY); dry rocky grassy flat, Lower McKittrick Canyon, Guadalupe Mts., Culberson Co., July 23, 1931 *Moore & Steyermark 3598* (G, M, NY); 1851–52, *Wright 1695* (F, G, NY), and *1696* (G, M, NY, US); May–Oct., 1849, *Wright 564* (C, F, G, NY, P, US); 1851, *Wright 248* (G); western Texas, *Wright 11935* (M); Rio Grande, 1848, *Wright* (G); lower slopes of Guadaloupe Mts., Aug. 28, 1916, *Young* (G, M); Davis Mts., Aug. 8, 1914, *Young* (M).

MEXICO:

NUEVO LEON: Monterrey, Sta. Catarina, La Fama, alt. 680 m., July, 1911, *Arsène & Abbon 6148* (M, NY, US).

COAHUILA: Saltillo, 1898, *Ed. Palmer 118* (C, F, NY, US); mountains north of Monclova, Feb.–Oct., 1880, *Ed. Palmer 792* (US); Juarez, Feb.–Oct., 1880, *Ed. Palmer 794* (US); mountains 24 mi. n. e. by n. from Monclova, first six days of September, 1880, *Ed. Palmer 792* (G, P); Juarez, about 100 miles north from Monclova, on the Sabinas River, Sept. 23–24, 1880, *Ed. Palmer 794* (F, G); near Parras, Oct., 1910, *Purpus 5004* (C, G); Sierra de Parras Oct. 1910, *Purpus 5022* (F, M, NY, US).

CHIHUAHUA: Santa Eulalia Mts., Sept. 26, 1885, *Pringle 539* (M).

PUEBLA: Acatzingo, Feb. 1, 1902, *Arsène 10* (F).

WITHOUT STATE: San Luis Potosi to San Antonio, Aug. 1878, *Parry* (P).

13. **M. scoparia** Engelm. ex A. Gray in Bot. Calif. **1**: 471. 1876; A. Gray, Syn. Fl. N. Am. **2**^{1}: 78. 1878; Rothrock in Rept. Wheeler Exp. 185. 1878; Hemsl. Biol. Cent.-Am. Bot. **2**: 304. 1881; Knobl. in Engler & Prantl, Nat. Pflanzenf. **4**^{2}: 14. 1895; Standl. in Contr. U. S. Nat. Herb. **23**: 1137. 1924; Jepson, Man. Fl. Pl. Calif. 761. 1925; Tidestrom in Contr. U. S. Nat. Herb. **25**: 413. 1925. Pl. 4, figs. 9–10.

M. scabra var. *glabrescens* Gray in Watson, Cat. Pl. Wheeler Exp. 15. 1874.

A paniculately branching, erect, suffruticose perennial, 3.5–9 dm. high; stems very numerous, much branched, opposite or clustered at the base, simple and elongated above, strict, slender, slightly angled, mostly glabrous or less often scaberulent; internodes elongated above; leaves opposite below, subalternate above, relatively few, including the petiole, 1–30 mm. long, 1–4 mm. broad, acute to obtusish, entire, mostly glabrous or sparsely scaberulent on the margins and upper surface, the lower slightly crowded, well developed, subpetiolate, oblong-obovate to oblanceolate, the upper remote, rudimentary, subsessile, linear or linear-subulate; flowers few, disposed in loose pleiochasial subcorymbose cymes; pedicels slender, 3–10 mm. long, glabrous or sparsely scaberulent, erect in fruit; calyx campanulate, 3–6 mm. long, glabrous or sparsely scaberulent; calyx-tube 1.5–2.25 mm. long, in anthesis about 2 mm. broad, in fruit about 4 mm. broad, mostly glabrous, rarely sparsely scaberulent; lobes usually 5–6 (infrequently with intermediate, smaller and narrower lobes, making 7, 8, or 10), linear to lanceolate, 1.5–4 mm. long, 0.5–1 mm. broad, acute to acuminate, entire, mostly glabrous, infrequently sparsely scaberulent on the margins; corolla subrotate, usually 9–10 mm. (sometimes 12–13 mm.) long, yellow; corolla-tube short, 3–5 mm. long, about 3 mm. broad at the orifice, moderately pilose at the orifice within; lobes 5, obovate, more or

less obtuse, 5–8 mm. long, 3–4 mm. broad; stamens slightly exserted, 7–9 mm. long; connective slightly prolonged into a blunt, cylindrical protuberance; pollen grain finely and irregularly reticulate, 75–87.5 μ in diameter; pistil 7–10 mm. (rarely 12–13 mm.) long; ovules 4 in each cell; stigma capitate; capsule 4–6 mm. long, about 10 mm. broad; seeds 4 in each cell, rather coarsely and regularly reticulate, 4–5 mm. long, about 3 mm. broad.

Distribution: Arizona to southeastern California and Lower California, south to Coahuila and Nuevo Leon, Mexico.

Specimens examined:

United States:

Arizona: Skull Valley, Fort Whipple, June 4, 1865, *Coues & Ed. Palmer 223* (M); Pinery Creek, Chiricahua Mts., Aug., 1896, *Fernow* (US); steep slopes, Roosevelt Dam, Aug. 3, 1911, *Gooding 720* (G, NY); Yucca, May 14, 1884, *M. E. Jones* (POM); Yucca, May 17, 1884, *M. E. Jones 3924* (NY, POM, US); above Cornville, Aug. 20, 1921, *W. W. Jones* (M); Prescott, July 17, 1927, *Peebles, Harrison & Kearney 4261* (US); Peach Springs, July 6, 1883, *Rusby* (F, M, NY, P); stones and gravel, Peach Springs, 1883, *Rusby 266* (G); Prescott, Aug. 24, 1894, *Toumey* (C); Payson, June 23, 1892, *Toumey 206b* (US); 1874, *Wheeler* (G); 20 mi. from Kingman, May 20, 1893, *Wilson* (C, US); Prescott, July 31, 1911, *Wooton* (US).

California: hills at Jacumba near the monument, San Diego Co., May 29, 1903, *Abrams 3641* (NY); dry gravelly hills, Jacumba, San Diego Co., May 29, 1903, *Abrams 3641* (C, G, M, NY, P, POM, US); Providence Mts., June 6, 1902, *T. S. Brandegee* (C); *Cooper* (US); at Fort Mojave, 1860–61, *Cooper* (G); dry hillsides, Jacumba, San Diego Co., alt. 854 m., May 22, 1924, *Fendge 557* (POM); rocky slopes, Providence Mts., alt. 1525 m., May 15, 1930, *Hoffmann* (St. B.); dry hills, Jacumba, San Diego Co., Aug. 13, 1917, *Munz 1683* (POM); dry slopes at base of mts., vicinity of Bonanza King Mine, east slope Providence Mts., Mojave Desert, May 21–24, 1920, *Munz, Johnston & Harwood 4264* (POM, US); San Diego Co., 1875, *Ed. Palmer* (G); San Diego Co., June, 1880, *S. B. & W. F. Parish 435* (M); Sorkin's Station, San Diego Co., June, 1880, *S. B. & W. F. Parish 435* (P); San Felipe, San Diego Co., June, 1882, *S. B. & W. F. Parish*

435 (F, NY); New York Mts., near Leastalk, San Bernardino Co., June 3, 1915, *S. B. Parish 10260* (C).

MEXICO:

LOWER CALIFORNIA: Las Huevitas, May 19, 1889, *T. S. Brandegee* (C); Agua Dulce, May 16, 1889, *T. S. Brandegee* (C); San Julio Cañon, April 20, 1889, *T. S. Brandegee* (F, G); El Rancho Viejo, April 24, 1889, *T. S. Brandegee* (P, US); Jacumba, alt. 854 m., July 9, 1922, *Fisher 36* (US); Cañon Cantillas, July 7, 1884, *Orcutt* (F); Cantillas Cañon, Aug. 1, 1883, *Orcutt* (C); Cantillas Mts., Aug. 1, 1883, *Orcutt 949* (G); Colton, June, 1880, *Vasey 362* (F, US).

COAHUILA: San Matias Pass, north end of San Pedro Mártir Mts., alt. 915 m., June 28, 1905, *Goldman 1181* (US); on mountains, about Saltillo, Sept. 1848, *Gregg 527* (G, M TYPE), and Merilla, 1848–49, *Gregg 527* (NY); on mountains at La Azufrora, near Saltillo, Sept. 22, 1848, *Gregg 498* (M); Bofecillos Mts., Sept., 1883, *Havard* (US); Feb. to Oct., 1880, *Ed. Palmer 795* (G, P, US); Cerro de Zapatero, July, 1910, *Purpus 4497* (C, M, US); rocks, near Pena, Feb. 1905, *Purpus* (C).

NUEVO LEON: Monterrey, 1924, *Orcutt 1318* (US).

14. M. intricata T. S. Brandegee in Univ. Calif. Publ. Bot. **4**: 380. 1913; Standl. in Contr. U. S. Nat. Herb. **23**: 1138. 1924.
Pl. 4, figs. 7–8; pl. 9, fig. 2.

A branching, erect, subherbaceous perennial, 2.5–4 dm. high; stems opposite or approximate, numerous, divergently branched, conspicuously ribbed, simple below, intricate above, glabrous or rarely sparse-puberulent on the margins of the decurrent petioles; internodes elongated; leaves opposite or becoming approximate above, sessile, few, remote, rudimentary, linear to linear-cuneate, 2–9 mm. long, 0.3–1 mm. broad, acuminate, entire or trifid, sparsely ciliate on the margins, fleshy; flowers rather numerous, terminating the branches of a loosely flowered cyme; pedicels slender, 3–9 mm. long, mostly glabrous, erect in fruit; calyx narrowly turbinate, 4–6 mm. long, mostly glabrous or sparsely hirtellous on the margins of the lobes; calyx-tube short, about 2 mm. long, in anthesis 1–1.5 mm. broad, in fruit 2 mm. broad; lobes 7–11, linear, acuminate, entire, 3–5 mm. long, about 0.3 mm.

broad; corolla shortly infundibuliform, about 10–12 mm. long, golden-yellow; corolla-tube slightly elongated, ampliate, 4–6 mm. long, about 2 mm. broad at the orifice, densely pilose at the base of the throat within; lobes 5–6, oblong-obovate, obtuse, 6–7 mm. long, about 3 mm. broad; stamens exserted, 7–8 mm. long; filaments glabrous, connective inconspicuously prolonged at the apex into a short, acute protuberance; pollen grain minutely and irregularly reticulate, appearing papillate, 62.5–75; (78.75) μ in diameter; pistil 8–10 mm. long; ovules 4 in each cell; stigma slightly capitate; capsule small, about 3 mm. long, twice as broad; seeds 4 in each cell, 2 mm. long, about 1.5 mm. broad, finely and irregularly reticulate, the ridges rather prominent.

Distribution; State of San Luis Potosi, Mexico.

Specimens examined:

Mexico:

San Luis Potosi: Minas de San Rafael, May, 1911, *Purpus 5016* (C type, G, NY, US); same locality, July, 1911, *Purpus 5016* (F, G, M, US); same locality, Nov. 1910, *Purpus 5044* (C).

14a. Var. **Purpusii** Steyermark, n. var.[43]

A nearly herbaceous perennial, 0.6–1.2 dm. high, more or less scabrous throughout; leaves 1.5–4 mm. long, 0.3–0.5 mm. broad; corolla 8–10 mm. long, with acute lobes.

Distribution: mountains near Tehuacan, state of Puebla, Mexico.

Specimens examined:

Mexico:

Puebla: mountains, Tehuacan, June, 1905, *Purpus 1318* (C, F, G, M type, NY).

15. M. juncea Harvey, Gen. So. Afr. Pl. ed. 2. 220. 1868; Harvey in Fl. Cap. 4:484. 1907. Pl. 10, fig. 1.

An erect, paniculately branched, suffruticose perennial, 6–9 dm. high; stems numerous, divaricate, strict, slender, terete, striate, mostly glabrous or minutely puberulent; internodes elong-

[43] Var. **Purpusii** Steyermark, var. nov., subherbacea perennis, 0.6–1.2 dm. alta, plus minusve scabrosa; foliis 1.5–4 mm. longis, 0.3–0.5 mm. latis; corolla 8–10 mm. longa, lobis acutis.—type collected in mountains, Tehuacan, state of Puebla, Mexico, June, 1905, *Purpus 1318* (M).

ated; leaves opposite, sessile, sparse, reduced to mere vestiges, remote, linear, 2–5 mm. long, 1 mm. broad, acute, entire, glabrous or minutely puberulent; flowers relatively numerous in paniculate cymes; pedicels slender, 6–15 mm. long, puberulent, erect in fruit; calyx campanulate, 5–7 mm. long, glabrous or minutely puberulent on the tube and margins of the lobes; calyx-tube 2–3 mm. long; lobes 5, linear, acute, entire, 3–5 mm. long, about 0.75 mm. broad; corolla about 9 mm. long; corolla-tube about 3 mm. long; capsule 6–8 mm. long, 8–10 mm. broad; seeds not seen.

There is a specimen of this species cited in the 'Flora Capensis' as having been collected by Whitehead near Modderfontein in Namaqualand. If this record is correct, then the range of this species should be considerably extended to the western extremity of South Africa.

Distribution: South Africa.

Specimens examined:

AFRICA:

UNION OF SOUTH AFRICA: clearings of Gouritz River, Georg, Karroo, Dec., *Ecklon & Zeyher* (BER, M).

16. M. robusta (Benth.) A. Gray in Am. Jour. Sci. II. **14**: 43. 1852; Walp. Ann. Bot. **5**: 487. 1858; Knobl. in Engler & Prantl, Nat. Pflanzenf. **4**^{2}: 14. 1895; Macloskie in Rept. Princeton Univ. Exp. to Patagonia (Bot.) **8**^{2}: 658. 1905.

Pl. 4, fig. 3; pl. 10, fig. 2.

Bolivaria robusta Benth. in Hook. London Jour. Bot. **5**: 190. *pl. 5.* 1846.

An erect, divergent, corymbosely branched, spinescent shrub, 6–11 dm. high; stems opposite, rather numerous, ascending, rigid, terete, becoming gradually pungent at the ends of the branches to produce a spinescent condition, covered with numerous, minute warty growths, densely puberulent, fleshy; leaves opposite, sessile, sparse, joined transversely at the base by a suture, reduced on the main branches to small, inconspicuous, cuneate scales, about 1 mm. long, 1–1.5 mm. broad, entire, glabrous, appearing on the short axillary spinescent branches, small, slightly petioled, oblong to linear-obovate, obtuse, entire, densely puberulent, including the petiole, 3–5 mm. long, 1–2 mm. broad; flowers

relatively few, appearing close together at the upper extremities of the main branches, terminal and solitary on the short, slender, axillary branchlets; pedicels densely puberulent, practically sessile, about 2 mm. long; calyx campanulate, 5–6 mm. long; calyx-tube 4 mm. long, about as broad, mostly glabrous; lobes 5–6, deltoid to more or less lanceolate, 2 mm. long, 0.75 mm. broad, entire, acute, puberulent on the margins; corolla infundibuliform, 22–25 mm. long, bright yellow; corolla-tube relatively elongated, about 12 mm. long, 7–8 mm. broad at the orifice, densely pubescent at the base of the throat within; lobes 5–6, ovate, 8–9 mm. long, 6 mm. broad, obtuse, mucronate; stamens exserted, 18–20 mm. long; filaments densely pubescent with short hairs around the base, about 10 mm. long; connective prolonged at the apex into a short, triangular protuberance; pollen grain large, with very large and rather regular reticulations, (66.25); 72.5–81.25; (91.25) μ in diameter; pistil about 25 mm. long; ovules 4 in each cell; stigma slightly capitate; capsule not seen. In regard to the capsule, Bentham says, "Didymous . . . dehiscence, unknown, however."

Distribution: east-central to southern Argentina.

Specimens examined:

South America:

Argentina: Territory Santa Cruz, alt. 50 m., Oct. 14, 1929, *Donat 182* (M); conglomerate uplands, General Roca and vicinity, Rio Negro Valley, alt. 250–360 m., Oct. 20, 1914, *Fischer 28* (US); vicinity of General Roca, Rio Negro, alt. 250–360 m., Sept. 1914–Feb. 1915, *Fischer 28* (C, F, G, NY); Travesia de Rawson á la Cordillera, territorio del Chubut, Nov. 1–30, 1903, *Illin 74* (C).

17. M. spinescens A. Gray in Proc. Am. Acad. **7**: 388. 1867; A. Gray, Syn. Fl. N. Am. **2**[1]: 78. 1878; Knobl. in Engler & Prantl, Nat. Pflanzenf. **4**[2]: 14. 1895; Tidestrom in Contr. U. S. Nat. Herb. **25**: 413. 1925; Jepson, Man. Fl. Pl. Calif. 760. 1925.

Pl. 4, figs. 1, 5–6; pl. 11.

An erect, divergent, irregularly branching shrub, 1.5–11 dm. high; stems numerous, stout, terete, slightly furrowed, the lower unarmed, the upper spinose, densely puberulent, the hairs closely

appressed; leaves alternate or fascicled, petiolate, including the petiole, 2–14 mm. long, 0.5–2 mm. broad, entire, fleshy, densely puberulent, the hairs closely appressed, conspicuous, numerous, crowded on the young branches and shoots, less conspicuous, smaller, scale-like or reduced to mere scars on the older and stouter branches, the alternate leaves linear-oblanceolate, acute, the fascicled leaves obovate-spatulate, obtuse or acute; flowers solitary or clustered, very small, numerous, terminating short axillary shoots from the upper parts of the branches; pedicels very short, 2–5 mm. long, glabrous to densely puberulent, erect in fruit; calyx turbinate to campanulate, 4–8 mm. long, glabrous or slightly puberulent; calyx-tube 1–2 mm. long, in anthesis 1–2 mm. broad, in fruit about 2 mm. broad; lobes 5 (rarely 6–8), broadly linear, 3–6 mm. long, about 0.5 mm. broad, obtuse, entire, acute; corolla infundibuliform, 7–9 mm. long, white, tinged brownish-purple without; corolla-tube relatively elongated, more or less abruptly expanded at the orifice, 4–6 mm. long, about 2 mm. broad at the orifice, slightly pubescent with slender short hairs along the length of the throat within; lobes 5, obovate, about 3–3.5 mm. long, 2–2.5 mm. broad, obtuse; stamens only slightly exserted, about 5 mm. long; filaments glabrous, connective not prolonged at the apex; pollen grain small, moderately and regularly reticulate (33.75); 39.9–50 μ in diameter; pistil 5–6 mm. long; ovules 2 in each cell; stigma small, inconspicuous; capsule 5–7 mm. long, 12–14 mm. broad; seeds 2 in each cell, 5–6 mm. long, about 3–4 mm. broad, finely and regularly reticulate.

Distribution: southern and west-central Nevada and adjacent California.

Specimens examined:

The writer has examined numerous mature capsules of this species, but in no instance is there any manifestation of dehiscence. The seeds seem to escape only after the membranaceous pericarp of the cocci, after a period of time, has been broken irregularly in places where punctures of one kind or another have occurred.

Specimens examined:

United States:

Nevada: s. e. part of Nevada, 1865, *Anderson* (G type); Jean,

Clark Co., May, 1915, *K. Brandegee* (C); summit between Basalt and Sand Spring, Esmeralda Co., Sept. 2, 1926, *R. S. Ferris 6678* (DS); Mormon Mts., Lincoln Co., alt. 915–1830 m., July, 1906, *Goodding 134* (C); Amargosa Desert, alt. 915 m., April 16, 1907, *M. E. Jones* (POM); Indian Spring, Charleston Mts., alt. 1403 m., May 7, 1906, *M. E. Jones* (POM); Good Springs, April 30, 1905, *M. E. Jones* (POM); Good Springs, May 1, 1905, *M. E. Jones* (POM); Rhyolite, alt. 1159 m., April 11, 1907, *M. E. Jones* (DS, POM); near Columbus Marsh, June 17, 1927, *M. E. Jones* (POM); Candelaria, June 22, 1882, *M. E. Jones* (POM); Mormon Mts., Lincoln Co., alt. 915–1830 m., July, 1906, *Kennedy & Goodding 134* (NY, US); Sodaville, Mineral Co., *S. B. Parish* (C); sandy soil, palmetto range, alt. 1525–1830 m., May–Oct., 1898, *Purpus 5903* (C, NY, US); Tonopah, alt. 1830 m., May, 1907, *Shockley 106* (C); Candelaria, Mineral Co., *Shockley 17* (C); Candelaria, Mineral Co., May, 1881, *Shockley* (G); base of Mt. Montgomery, near Queen station, alt. 1850 m., June 20, 1919, *Tidestrom 10034* (US); on slopes of the Covillea belt, Goodsprings, alt. 1125 m., April 19, 1919, *Tidestrom 8907* (US); in cañon, Montezuma Mt., near Goldfield, alt. 2100 m., June 4, 1919, *Tidestrom 9775* (US).

California: Barnwell, May, 1911, *K. Brandegee* (C); Good Springs, May, 1915, *K. Brandegee* (US); Providence Mts., at Fort Mojave, 1860–61, *Cooper* (DS, G); Funeral Mts., Inyo Co., March 21 and 22, 1891, *Coville & Funston 458* (US); Government Holes, Cima Road, 6 mi. from Cima, alt. 1403 m., San Bernardino Co., April 25, 1928, *Ferris 7325* (DS, NY); common at the head of Furnace Creek wash on Death Valley Junction road, Inyo Co., March 17–24, 1924, *Ferris, Scott & Bacigalupi* (DS); Dante's View, Death Valley, May 1, 1927, *Gilman 2* (POM); See Flat, 15 mi. n. of Darwin, Inyo Co., alt. 1586 m., Sept. 28, 1917, *Grinnell* (C); western slope, Argus Mts., Lower Sonoran zone, Inyo Co., alt. 1738.5 m., May 19, 1906, *Hall & Chandler 7096* (C); sand hills west of Laws, Inyo Co., May 8, 1906, *Heller 8202* (DS, F, G, M, NY, P, US); gravelly mesa, Ryan to Shoshone, April 4, 1929, *Hoffmann* (St. B); common in stony washes, Granite Pass, San Bernardino Co., alt. 976 m., May 18, 1930, *Hoffmann* (St. B); sandy flat, 7 mi. s. w. of Darwin, Inyo Co., alt. 1372.5 m., April

27, 1930, *Hoffmann* (St. B.); Funeral Mts., Death Valley region, *Jaeger* (POM); chloride cliff, Funeral Mts., alt. 1220 m., May 8, 1920, *Jaeger 66* (US); Darwin, alt. 1403 m., April 28, 1897, *M. E. Jones* (POM); Cove Spring, Old Dad Mt., May 14, 1926, *M. E. Jones* (POM); 7 mi. e. of Dante's Point, Death Valley region, Inyo Co., alt. 1372.5 m., April 5, 1928, *Munz & Hitchcock 11022* (POM).

17a. Var. **mohavensis** Steyermark, n. var.[44]

Corolla broadly infundibuliform, 12–15 mm. long; corolla-tube gradually ampliate towards the orifice, 10–12 mm. long; lobes about 4–4.5 mm. long, 3.5–4.5 mm. broad; stamens about 10 mm. long; connective prolonged at the apex into a short, rounded protuberance; pollen grain 43.75–56.25 μ in diameter; pistil 13–14 mm. long; seeds about 7 mm. long, about 5 mm. broad.

Distribution: Mohave Desert of southeastern California.

The characters of the much larger corolla and the more broadly infundibuliform corolla-tube, more ampliate towards the orifice, combined with the limited distribution in the Mohave Desert, seem to warrant treating this as a variety of *M. spinescens*.

Specimens examined:

United States:

California: dry open desert, 13 mi. n. of Barstow, San Bernardino Co., alt. 640.5 m., April 30, 1924, *Fendge 558* (POM); Ordinance Mts., Mohave Desert, Lower Sonoran zone, San Bernardino Co., April 30, 1906, *Hall & Chandler 6780* (C); Funeral Mts., bordering Death Valley, May 15, 1920, *Jaeger 1131* (POM); Calico Mts., Coolgardie Yucca Mesa, Mohave Desert, March 27, 1916, *Jepson 6635* (G); Leastalk, Mohave Desert, San Bernardino Co., June 5, 1915, *S. B. Parish 10360* (DS); plains, Leastalk, Mohave Desert, San Bernardino Co., June 3, 1915, *S. B. Parish 10361* (C); 14 mi. n. e. of Barstow, Mojave Desert, San Bernardino Co., April 23, 1915, *S. B. Parish 9795* (C type, DS); in

[44] Var. **mohavensis** Steyermark, var. nov., corolla late infundibuliformi, 12–15 mm. longa; corollae tubo sensim dilatato 10–12 mm. longo; staminibus circiter 10 mm. longis, connective elongato apice in protuberans breve subglobosum; polline 43.75–56.25μ in diametro; seminibus circiter 7 mm. longis, 5 mm. latis.—type collected 14 miles n.e. of Barstow, Mojave Desert, San Bernardino Co., April 23, 1915, *S. B. Parish 9795* (C).

desert sand, Barstow, Mohave Desert, alt. 640.5 m., April 23, 1921, *Spencer 1776* (G).

Species Imperfectly Known

M. linoides Phil. in Linnaea 33: 173. 1864.

A low, suffruticose, smooth perennial, simulating *Linum aquilinum* Mol. in appearance; leaves slightly exceeding the internodes, opposite, exstipulate, numerous, broadly linear, 10 mm. long, about 2.5 mm. broad, very shortly acuminate, erect, the highest the smallest, bract-like, glabrous, subcoriaceous; flowers few, 1–3, terminal; pedicel 3.1 mm. long; calyx in anthesis 4.2 mm. long, in fruit 6.8–7.3 mm. long, cleft to the middle; lobes 5, narrowly linear, prominently nerved in the middle; corolla light yellow, purplish on the outside, infundibuliform, 14.7 mm. long; corolla-tube short, pilose within; lobes ovate-oblong or ovate; stamens equalling ⅔ of the corolla; filament very long; anthers linear, about 4.2 mm. long; style equalling the stamens; stigma capitate, obscurely 3-lobed; ovules 2 in each cell, erect, paired; mature fruit not present.—TYPE collected between Chincolco and Concumen in the province of Aconcagua, Chile, *Landbeck*.

Compiled from the original description.

M. chlorargantha Remy in Ann. Sci. Nat. Bot. III. 8: 225. 1842.

A branching shrub, about 3 dm. high; stems numerous, slender, dichotomously branched, glabrous; leaves opposite or the highest alternate, slightly petiolate, oblong-lanceolate, 18.5–23 mm. long, about 3.5 mm. broad, entire, acute, glabrous, subcoriaceous; flowers terminal; pedicel 1-flowered; calyx campanulate, glabrous; lobes 6–7, linear, entire, glabrous, obtuse; corolla infundibuliform, twice exceeding the calyx in length, yellowish-white; lobes 6–7, oval-oblong, obtuse; stamens included; anthers ovate; style equalling the stamen in length; stigma capitate, obscurely bi-lobed; seeds 3–4 in each cell, erect, ovate, trigonal.—TYPE collected in hills around Chuquisaca, Bolivia, *d'Orbigny* (Herb. Mus. Paris).

Compiled from the original description.

List of Exsiccatae

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Explanation of Plate

PLATE 4

Fig. 1. Pollen grain of *M. spinescens*, looking down on flat surface. × 180.

Fig. 2. Pollen grain of *M. africana*, looking down on convex surface, showing the three germinal apertures. × 180.

Fig. 3. Pollen grain of *M. robusta*, looking down on convex surface, showing the three germinal apertures. × 180.

Fig. 4. Pollen grain of *M. longiflora*, looking down on convex surface, showing the three germinal apertures. × 180.

Fig. 5. Seed of *M. spinescens*, showing convex outer surface. × 7.

Fig. 6. Same as fig. 5, showing concave inner surface. × 7.

Fig. 7. Seed of *M. intricata*, showing ridge and two flattened faces. × 7.

Fig. 8. Same as fig. 7, showing the convex outer surface. × 7.

Fig. 9. Seed of *M. scoparia*, showing ridge and two flattened faces. × 7.

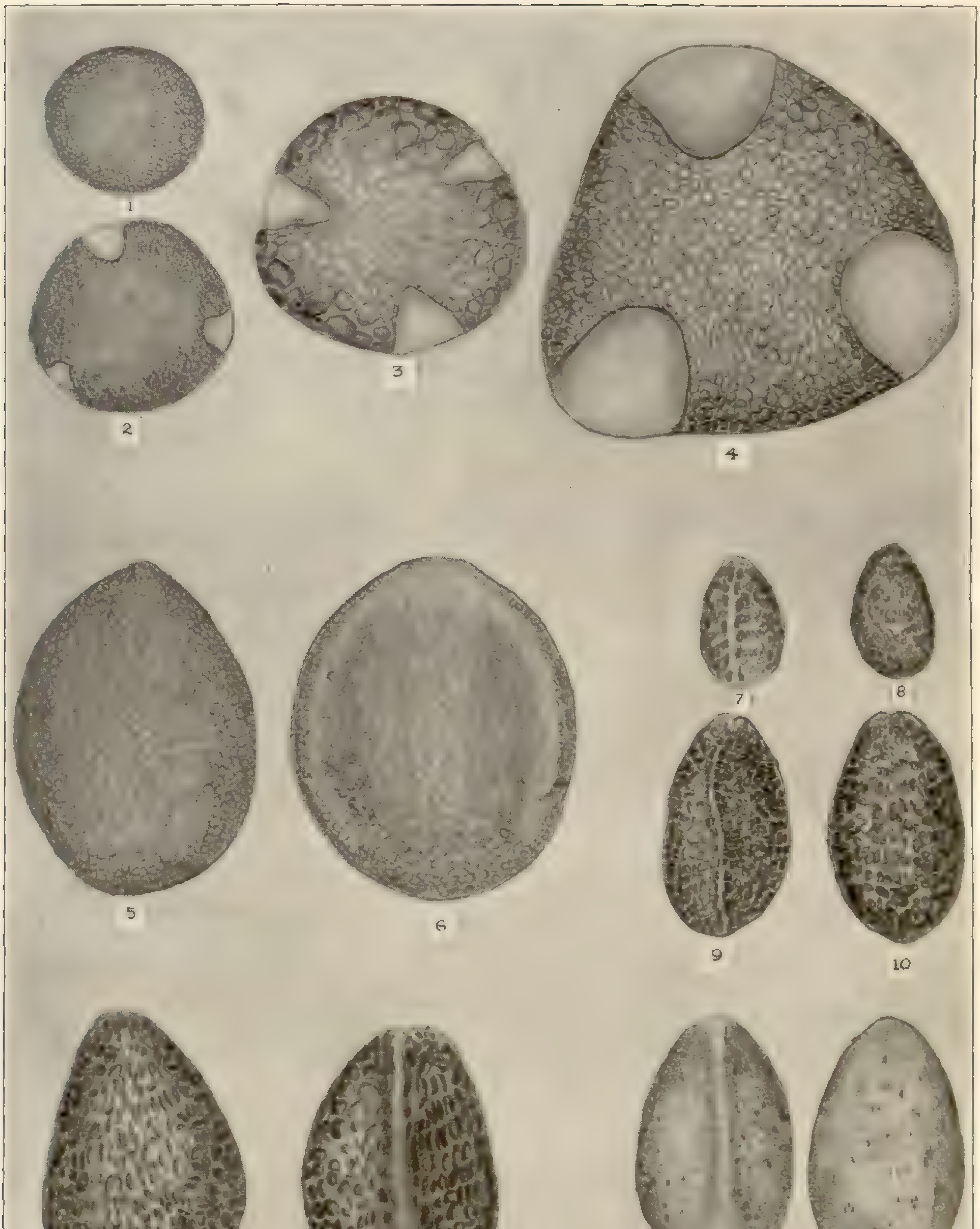
Fig. 10. Same as fig. 9, showing the convex outer surface. × 7.

Fig. 11. Seed of *M. heterophylla*, showing the convex outer surface. × 7.

Fig. 12. Same as fig. 11, showing ridge and two flattened faces. × 7.

Fig. 13. Seed of *M. scabra*, showing ridge and two flattened faces. × 7.

Fig. 14. Same as fig. 13, showing the convex outer surface. × 7.



STEYERMARK—REVISION OF MENODORA

Explanation of Plate

PLATE 5

Fig. 1. *Menodora helianthemoides* HBK. var. *Engelmannii* Steyermark, n. var.
From an authentic specimen, *Ed. Palmer 164*, in the University of California Herbarium.

Fig. 2. *Menodora africana* Hook.
From an authentic specimen, *Wood 7948*, in the Herbarium of the Field Museum of Natural History.

1

2

STEYERMARK—REVISION OF MENODORA

Explanation of Plate

PLATE 6

Fig. 1. *Menodora heterophylla* Moric.

From an authentic specimen, *Reverchon 1328*, in the Herbarium of the Field Museum of Natural History.

Fig. 2. *Menodora heterophylla* Moric. var. *australis* Steyermark, n. var.

From the type specimen, *Pegler 950*, in the Herbarium of the Botanical Garden and Museum of Berlin-Dahlem.

1

2

STEYERMARK—REVISION OF MENODORA

Explanation of Plate

PLATE 7

Fig. 1. *Menodora integrifolia* (Cham. & Schlecht.) Steud. var. *trifida* (Cham. & Schlecht.) Steyermark, n. comb.

From an authentic specimen, *Hassler 6475*, in the Gray Herbarium of Harvard University.

Fig. 2. *Menodora scabra* A. Gray.

From an authentic specimen, *Ed. Palmer 309*, in the Herbarium of the Field Museum of Natural History.

1

2

STEYERMARK—REVISION OF MENODORA

Explanation of Plate

PLATE 8

Fig. 1. *Menodora pinnatisecta* Steyermark, n. sp.

From the type specimen, *Jörgensen 2643*, in the Gray Herbarium of Harvard University.

Fig. 2. *Menodora decemfida* (Gill.) A. Gray.

From an authentic specimen, *Fielding*, in the Gray Herbarium of Harvard University.

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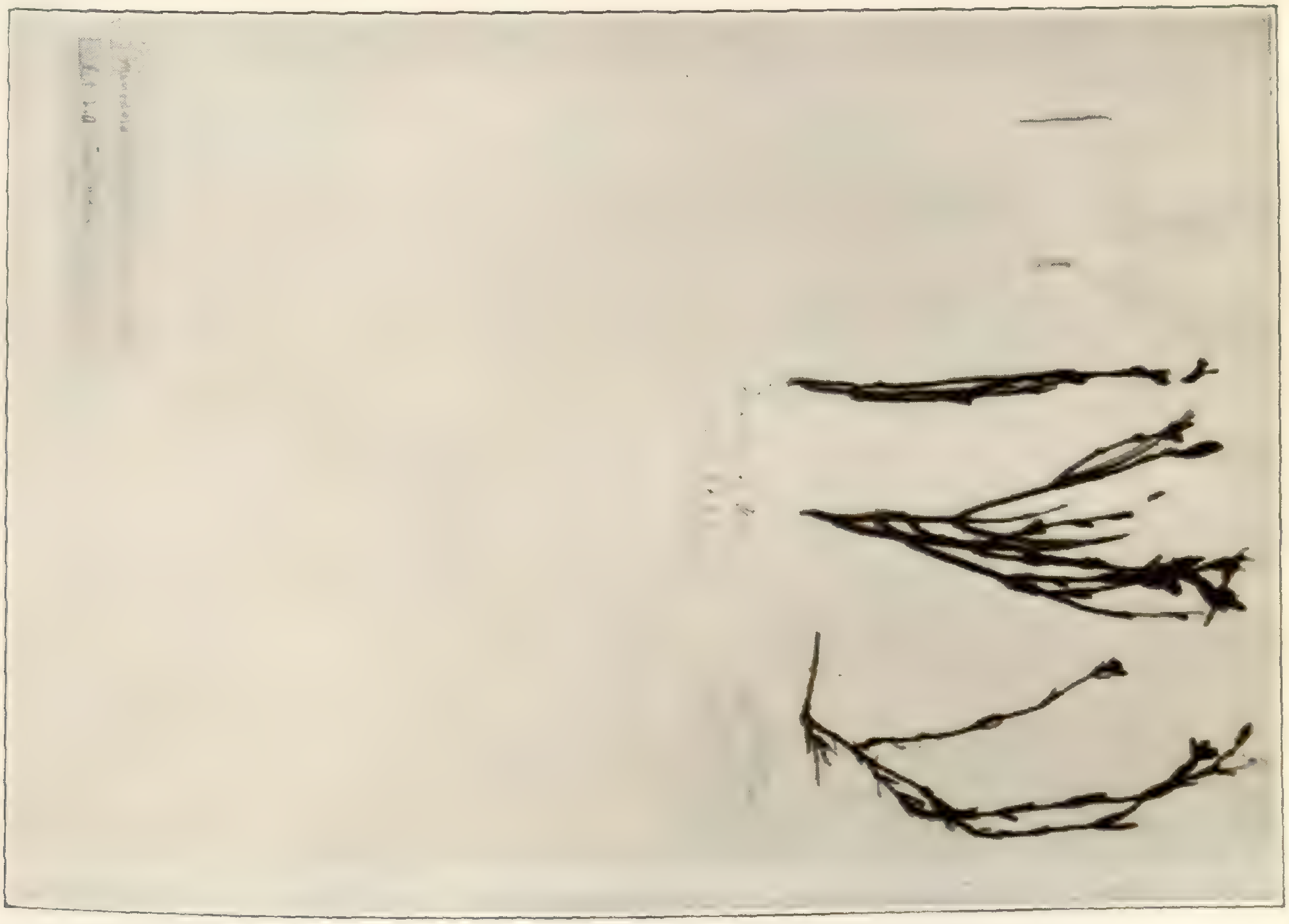

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STEYERMARK—REVISION OF MENODORA

Explanation of Plate

PLATE 9

Fig. 1. *Menodora longiflora* (Engelm.) A. Gray.

From an authentic specimen, *Wright 564*, in the Gray Herbarium of Harvard University.

Fig. 2. *Menodora intricata* Brandegee.

From the type specimen, *Purpus 5016*, in the Herbarium of the University of California.

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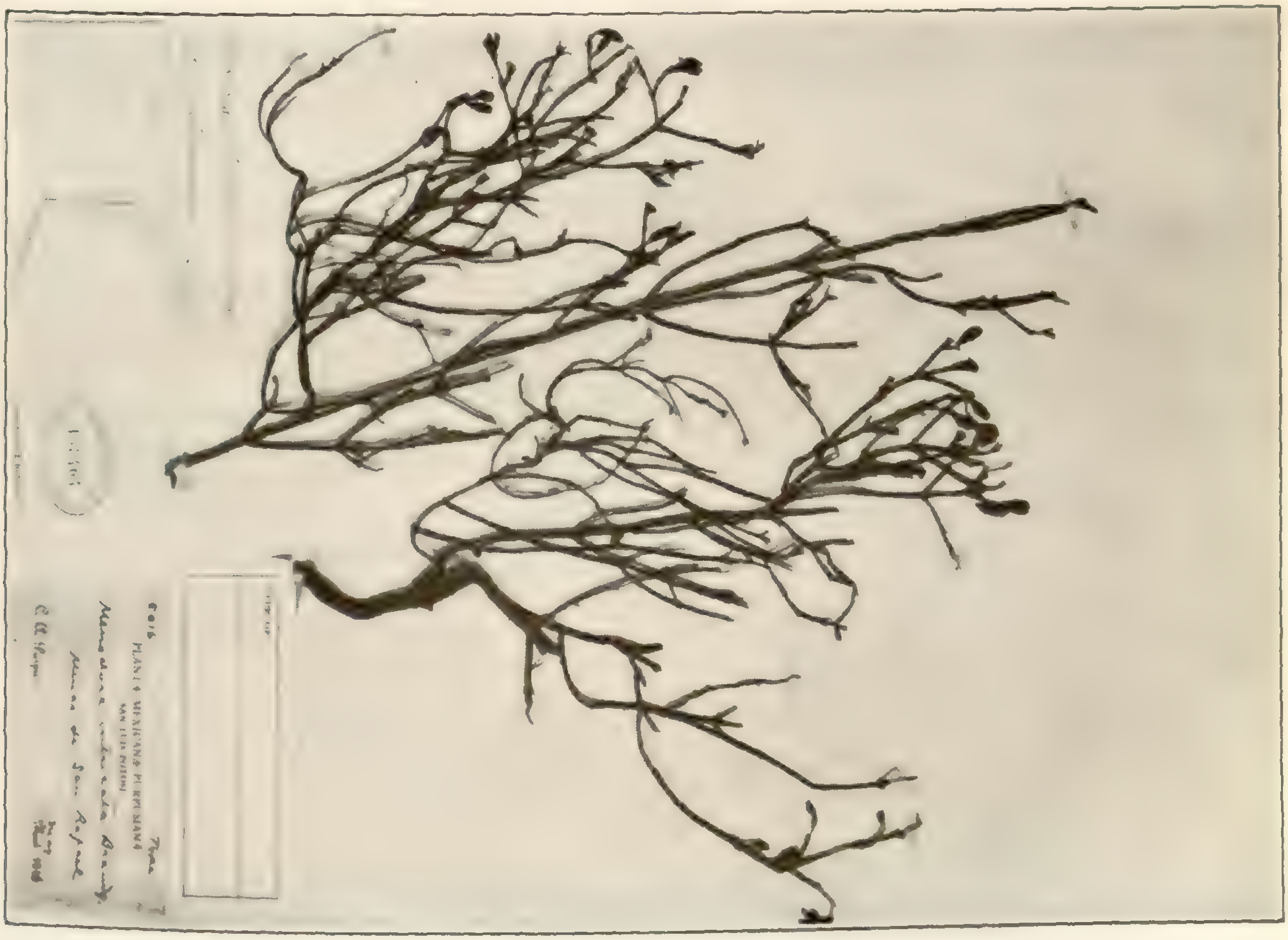

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STEYERMARK—REVISION OF MENODORA

Explanation of Plate

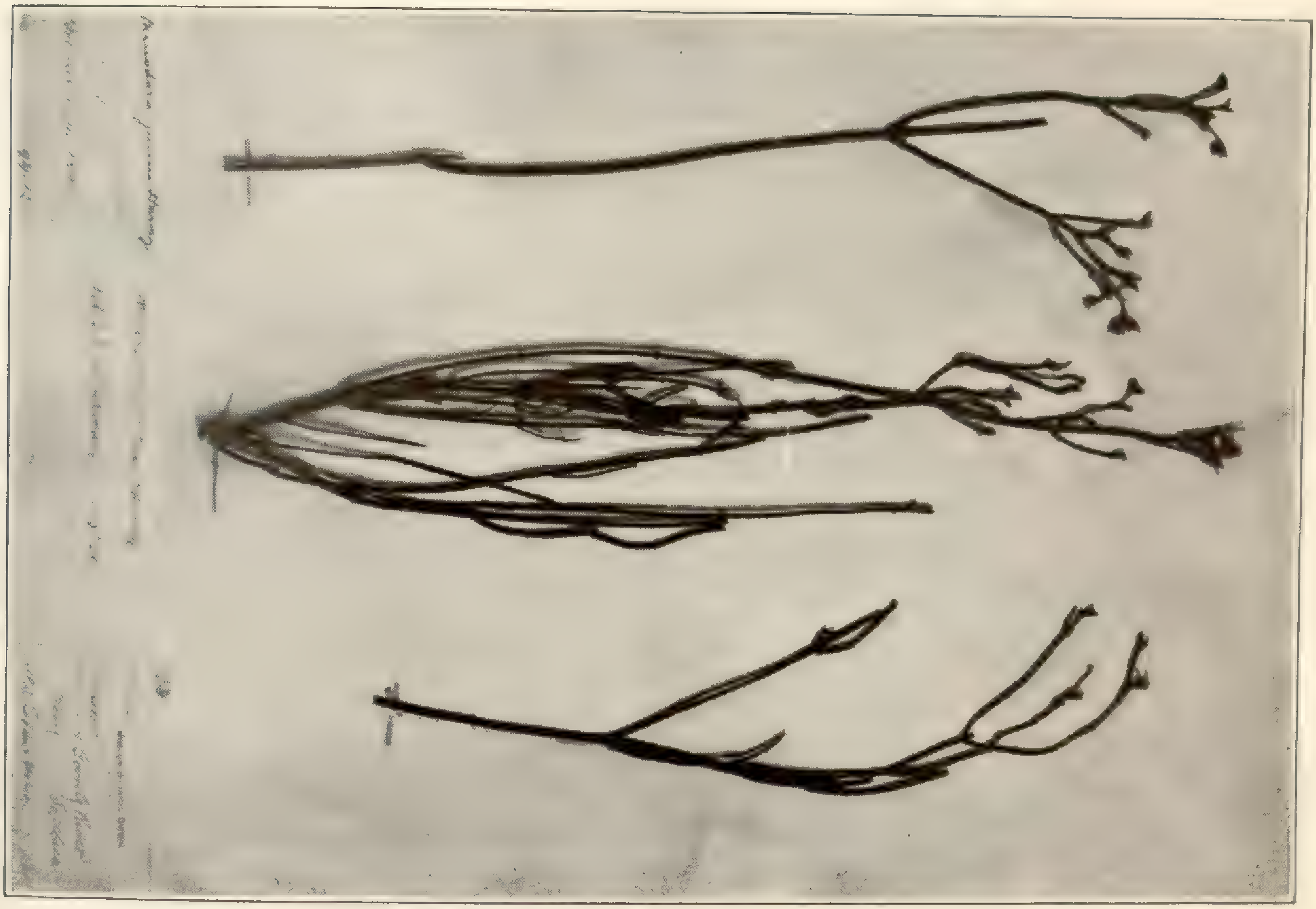
PLATE 10

Fig. 1. *Menodora juncea* Harvey

From an authentic specimen, *Ecklon & Zeyher "94.12"* in the Herbarium of the Missouri Botanical Garden.

Fig. 2. *Menodora robusta* (Benth.) A. Gray

From an authentic specimen, *Fischer 28,* in the Gray Herbarium of Harvard University.



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STEYERMARK—REVISION OF MENODORA

Explanation of Plate

PLATE 11

Menodora spinescens A. Gray
From an authentic specimen, *K. Brandegee,* in the Herbarium of the University of California.

STEYERMARK—REVISION OF MENODORA

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Annals of the Missouri Botanical Garden

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A NEW NAMA FROM IDAHO

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Among the plants sent recently to the Herbarium of the Missouri Botanical Garden is a *Nama* from the Snake River region of southern Idaho. A critical study of the plant indicates its relationship with *Nama demissum* Gray. The specimen in question, however, differs in important morphological characters from *N. demissum* and all other known species of the genus, hence it is described as new.

Nama psammophilum[1] Goodman, n. sp. Annual, depressed, 5–8 cm. high; stems branching and hirsute; leaves entire, narrowed to a winged petiole, the blade oblanceolate or elliptic, 1–2 cm. long, hispid, especially on the midrib and margin; cymes axillary and few-flowered, flowers shortly pedicellate; sepals linear-subulate, 8 mm. long, hirsute; corolla narrowly infundibuliform, 16–17 mm. long, sparsely hirsutulose, lobes orbicular, 4 mm. long; stamens unequal, attached near the middle of the corolla-tube; styles 7–8 mm. long, weakly cohering along the

[1] **Nama psammophilum** Goodman, sp. nov. Annuum, depressum, 5–8 cm. altum; caulibus ramosis et hirsutis; foliis integris in petiolum alatum attenuatis, lamina oblanceolata vel elliptica, 1–2 cm. longa, hispida praesertim in nervo medio et margine; cymis axillaribus paucifloris, floribus breviter pedicellatis; sepalis lineari-subulatis, 8 mm. longis, hirsutis; corolla anguste infundibuliformi, 16–17 mm. longa, sparse hirtella, lobis orbicularibus, 4 mm. longis; staminibus inaequalibus usque corollae medio tubo affixis; stylis 7–8 mm. longis, usque ad ¾ longitudinis parce connatis; ovario pseudobiloculari; capsula oblonga, seminibus immaturis, ovulis ca. 28.—Idaho: growing in sand, rim of Snake River Cañon, near Hagerman, May 22, 1930, *Miss Cora Shoop* (Mo. Bot. Gard. Herb. No. 1014289) TYPE.

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lower ¾ of their lengths; each of the two false cells of the oblong capsule containing about 14 ovules.—Idaho: growing in sand, rim of Snake River Cañon, near Hagerman, May 22, 1930, *Miss Cora Shoop* (Mo. Bot. Gard. Herb. No. 1014289) TYPE.

The cohering styles of this species technically place it in the section *Conanthus,* but other and more important morphological structures indicate its relationship elsewhere. The habit, leaf-outline, shape of the sepals and corolla, the level of insertion of the stamens, the number of ovules in the capsule, as well as the geographic distribution, all indicate the relationship of the new species with *Nama demissum* Gray. *Nama psammophilum* is easily distinguishable from *N. demissum* in having larger leaves, longer sepals, and larger corolla, as well as in having technical differences in the structure of the filaments. In *N. psammophilum* there are no wings along the portion of the filament which is adnate to the corolla, nor is there the slight geniculation of the filament at the point of insertion.

A MONOGRAPHIC STUDY OF THE GENUS LYCIUM OF THE WESTERN HEMISPHERE[1]

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Introduction

The present study was undertaken at the suggestion of Dr. Ivan M. Johnston, who pointed out the lack of a comprehensive systematic treatment of the American species of the genus *Lycium* and the related genera. The consummation of the work was made possible through the assistance of various individuals to whom the writer wishes to extend his thanks at this time. Dr. G. T. Moore, Director of the Missouri Botanical Garden, has placed the library and herbarium of that institution at the writer's disposal; Dr. J. M. Greenman, under whose direction this study has been carried on, has been most generous with his time and helpful suggestions; Dr. Mildred E. Mathias, assistant to Dr. Greenman during the year 1929–30, and Dr. A. L. Grant, acting curator of the herbarium during Dr. Greenman's absence in the fall of 1930, offered constructive criticism and were instrumental in obtaining herbarium and bibliographical material; Dr. D. H. Linder offered many valuable suggestions during the preparation of the illustrations, took the photographs, and helped assemble the plates; and Miss Nell Horner, librarian of the same institution, has kindly helped in the assembling of the literature relative to the genus.

Dr. I. M. Johnston has given freely of his time in looking up literature at the Gray Herbarium and has been very generous with his valuable knowledge of distribution, geography, and botanical history. Dr. J. H. Barnhart, of the New York Botanical Garden, and the librarians of the Field Museum, Smithsonian Institution

[1] An investigation carried out at the Missouri Botanical Garden in the Graduate Laboratory of the Henry Shaw School of Botany of Washington University, and submitted as a thesis in partial fulfillment of the requirements for the degree of doctor of philosophy in the Henry Shaw School of Botany of Washington University.

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at Washington, Gray Herbarium, and Arnold Arboretum have all been extremely kind in their assistance in bibliographical matters. The curators of the herbaria at the British Museum, Botanical Garden and Museum of Berlin-Dahlem, Botanical Museum at Munich, Royal Botanical Garden of Brussels, and Museum of Natural History at Paris have supplied information or photographs relative to the type material deposited in their herbaria. Mr. R. H. Peebles, of the U. S. Field Station at Sacaton, Arizona, has been most courteous in supplying an abundance of fresh material of all the species of *Lycium* found in southern Arizona, preparing excellent series of specimens showing the range of variation within the species, and submitting carefully prepared field notes on color, habit, and habitat; Mr. A. Castellanos, of the Museo Nacional de Historia Natural de Buenos Aires, contributed a very valuable series of plants from Argentina, most of which were not represented elsewhere.

The curators of the following herbaria have loaned the material at their disposal, in part, or in its entirety:

Brooklyn Botanical Garden through Dr. H. K. Svenson (B).
Museo Nacional de Historia Natural de Buenos Aires (BA).
University of California (C).
California Academy of Sciences (CA).
University of California at Los Angeles (UCLA).
Delessert Herbarium at Geneva (D).
Desert Laboratory of the Smithsonian Institution at Tucson, Arizona (DL).
Field Museum of Natural History (F).
Gray Herbarium of Harvard University (G).
Herbarium of Mr. A. O. Garrett, Salt Lake City, Utah (GAR).
Kew Herbarium (KEW).
Missouri Botanical Garden (MBG).
New York Botanical Garden (NY).
Philadelphia Academy of Natural Sciences (PA).
Pomona College (P).
U. S. Field Station, Sacaton, Arizona (SAC).
Santa Barbara Museum of Natural History (SBM).
Stockholm Botanical Museum (ST).
Leland Stanford University (S).

United States National Herbarium (US).
Herbario del Museo Comercial de Venezuela (Venez).
Natural History Museum of Vienna (V).

The abbreviations indicated in parentheses are those used in citing material in this paper. To these persons, and to various others who have helped in numerous details, I hereby acknowledge my indebtedness and gratitude.

History of the Genus

The genus *Lycium*, although established by Linnaeus in 1753, was known long before this time by some of the older systematists, the herbalists. Pliny[2] mentioned *Lycium* as a specific which was good for sore eyes, inflammation, and various ailments. He stated that 'the best lycium comes from a spiny plant called pyxacanthos chironia.' Dioscorides[3] devoted about a page and a half to *Lycium*, referring to the above treatment by Pliny. Concerning its occurrence, he said, "Nascit plurimum in Cappadocia, Lycia & plaerisque aliis locis." He stated also that the fruit is like that of *Piper*, and recommended concoctions from various parts of the plant for relieving inflammation and kindred ailments.

In the 'Species Plantarum,' Linnaeus[4] included three species under *Lycium*, namely, *L. afrum*, *L. barbarum*, and *L. europaeum*. Of these three species, *L. afrum* appears to be the plant with which he was most familiar, and it was with entire justification that Dr. Hitchcock[5] selected it as the standard species for the genus.

Medicus,[6] in 1789, revived the Pre-Linnaean name of *Jasminoides*, placing *L. afrum* under that genus; his generic name must therefore be relegated to synonymy. In 1808, Necker[7] split the genus *Johnsonia* from *Lycium*. His description does not distinguish his new segregate from the older genus, and since he

[2] Plinius Secundus, C. Naturalis historia, lib. 24, capi. 14. [ed. J. Dalechamp **2**: 1114. 1608.]

[3] Dioscorides: P. Dioscoridae pharmacorum simplicium reique medicae. lib. **8**[1]: 54c–55a. Io. Ruellio interprete. Argentorat, 1529.

[4] Linnaeus, Species plantarum **1**: 191. 1753.

[5] Hitchcock, A. S. Proposals by the sub-committee on nomenclature for the International Botanical Congress of 1930. 133. 1929.

[6] Medicus, Philosophische Botanik **1**: 134. 1789.

[7] Necker, Elementa botanica. ed. 2. **2**: 49. 1808.

did not list any species under *Johnsonia*, it too must fall to synonymy.

Kunth[8] treated the genus in three sections, based very largely upon characters of the calyx; however, he did not assign names to the divisions. The sections were:

1. "Calyx urceolatus, irregulariter 3–6-fidus; rarius (in Lycio boerhaaviaefolio) sinuato-quinquedentatus et regularis" etc. To this section he assigned *L. barbarum* and *L. europaeum*.

2. "Calyx urceolato-campanulatus, quinquedentatus-regularis" etc. Here, he placed *L. afrum*.

3. "Calyx urceolatus, saepissime irregulariter quinquefidus aut quinquedentatus" etc.

In 1838, Rafinesque[9] segregated several new genera from *Lycium;* and although his work is frequently disregarded, it must be taken into consideration here because of the synonymy his new genera have produced. He restricted the name *Lycium* to Kunth's first group, excluding a few of the elements therein. He then proposed the following new genera: *Pukanthus, Oplukion, Valteta, Diplukion, Ascleia, Teremis, Huanaca, Cantalea, Pederlea, Evoista,* and *Plicula,* all of which were very briefly characterized, so that some of them may be unquestionably reduced to synonymy under *Lycium.* It is interesting to note that he assigned *L. afrum* to his new genus *Oplukion.*

G. Don,[10] in 1838, used the three sections which Kunth had delimited, assigning names to these subdivisions of the genus, and listing thirty-four species. In the first section which he called *Eulycium,* "the true species of *Lycium,*" he placed twelve species, nine of which, including *L. europaeum* and *L. barbarum,* were from the Old World, three being South American. The second section was called *Isodontia,* and included nine species, one of them being *L. afrum.* Only one South American species was assigned to this group, the remainder being from the Old World. Under the third section, *Anisodontia,* seven species, all South American, were placed; *L. carolinianum,* the only North American plant mentioned, was included under the caption

[8] Kunth, Synopsis plantarum **2**: 179. 1823.

[9] Rafinesque, Sylva Telluriana. 52. 1838.

[10] G. Don, Gen. Hist. Dichl. Pl. **4**: 457. 1838.

"species hardly known." Thus it is seen that, like Kunth, Don placed *L. afrum* under a group other than "true *Lycium*"; in this procedure he was followed by most of the subsequent authors.

Endlicher[11] treated the genus under the three sections *Eulycium, Lyciobatos,* and *Lyciothamnos,* basing the groups upon much the same characters that Kunth had used, namely, those of the calyx; however, he did not list species under the subdivisions. Walpers[12] followed Endlicher's method of subdividing the genus, using Don's terminology, however, and enumerating thirty-nine species, fifteen of which were placed under *Eulycium,* eleven under *Isodontia,* seven under *Anisodontia,* and six under "species minus cognitae."

In 1845, Miers[13] created two new genera, *Lycioplesium* and *Chaenesthes,* to include some of the species formerly placed in *Lycium,* shifting the South American species, *L. obovatum, L. Meyenianum,* and *L. horridum,* to *Lycioplesium,* and giving most of the species of Endlicher's section *Anisodontia,* namely, *L. fuchsioides, L. umbrosum, L. gesnerioides, L. loxense,* and *L. cornifolium* to the genus *Chaenesthes.*

Dunal,[14] in 1852, divided the genus into four new sections, *Schistocalyx, Eulycium, Amblymeris,* and *Lyciobatos.* The diagnostic characters he used were varied, but were based very largely upon calyx characters; forty species were recognized. Following Dunal's work, Miers[15] published a treatment of the genus, disagreeing with Dunal in many respects. He divided the genus into three sections, *Brachycope, Mesocope,* and *Macrocope,* using corolla, rather than calyx, characters, and treating sixty-nine species, many of which were new. His disposition into sections was followed by Bentham and Hooker[16] and by Wettstein,[17] but the genus was placed in different tribes of the family by the latter two workers.

Terraciano[18] proposed a system of classification for the genus

[11] Endlicher, Genera plantarum. 667, no. 3863. 1841.

[12] Walpers, Rep. Bot. Syst. **3**: 106. 1844.

[13] Miers, Hook. Lond. Jour. Bot. **4**: 330. 1845.

[14] Dunal in De Candolle, Prodromus **13**^{1}: 508. 1852.

[15] Miers, Ann. & Mag. Nat. Hist. II, **14**: 7. 1854.

[16] Bentham & Hooker, Gen. Pl. **2**^{2}: 883. 1876.

[17] Wettstein in Engler & Prantl, Die Nat. Pflanzenfam. **4**^{3b}: 13. 1891.

[18] Terraciano, Malpighia **4**: 511. 1891.

in 1891 which is much too complicated to be of practical value. His concept of nomenclatural categories was radically different from that of any of the other workers in the Solanaceae, and his disposition of the New World species indicates that he did not have much knowledge of these members of the genus.

Aside from these more general treatments, species of North America have had an independent history from those of South America, and it is therefore more expedient to consider them in that light.

The first North American species to be described were *L. americanum*[19] and *L. carolinianum*,[20] both being made known to science in 1788. Dunal and Miers added new species in their respective publications, but Dr. Gray, working with the collections from the southwestern United States and Mexico, had occasion to publish by far the most of the species described from this continent. His synopsis of the genus in 1862[21] and his treatment of the group in the 'Synoptical Flora,'[22] where nineteen species and five varieties were maintained, are the only publications which cover the genus as a whole for the region under consideration. The various floras and manuals of the southwestern United States and Mexico need not be considered here since they add nothing material to the knowledge of the genus. The last paper of any significance is that of I. M. Johnston[23] dealing with the flora of Lower California, where seven species were listed and some of the problems relative to the status of *L. Richii* and *L. umbellatum* were straightened out.

The works of most importance concerning the South American species are those of Ruiz and Pavon,[24] Humboldt, Bonpland and Kunth,[25] Sendtner,[26] Remy,[27] Weddell,[28] and Philippi.[29] Among

[19] Jacquin, Stirp. Amer. Hist. 65. 1788.

[20] Walter, Fl. Carol. 84. 1788.

[21] Gray, Proc. Amer. Acad. **6**: 45. 1862.

[22] Gray, Syn. Fl. N. Amer. ed. 2. **2**[1]: 237, 437. 1886.

[23] Johnston, Proc. Calif. Acad. Sci. IV, **12**: 1153. 1924.

[24] Ruiz & Pavon, Flora Peruviana **2**: 45. 1799.

[25] Humboldt, Bonpland & Kunth, Nov. Gen. et Sp. Pl. **3**: 50. 1818.

[26] Sendtner in Martius, Flora Brasil. **10**: 153. 1846.

[27] Remy in Gay, Hist. Chile, Bot. **5**: 91. 1849.

[28] Weddell, Chloris Andina **2**: 108. 1857.

[29] Philippi, Florula Atacamensis. 43. 1860.

the more recent workers, Spegazzini, Rusby, P. Dusén, and U. Dammer have been perhaps the most instrumental in making species known to science, so that up to the present time there have been well over one-hundred species described from the Southern Hemisphere alone. Nowhere, however, has there been any attempt to straighten out the identity or the validity of these species, since Miers' paper, or even to present a key that the working botanists might use; therefore, the writer feels that any contribution he can make toward the interpretation of the specific and generic relationships of the North and South American Lycia will help to fill a definite need.

Morphological Characters of Taxonomic Value

Roots.—The root system of *Lycium* is relatively extensive in comparison with the aerial portion of the plant, frequently extending laterally as much as five or six meters, and attaining a thickness of two or more centimeters. They are extremely tough and fibrous, but present no characters of taxonomic significance.

Stems.—The stems vary considerably; they are, however, always perennial. A few species are dwarfed, the stem being but a few centimeters tall; in such instances, the plants are usually spreading in habit. In nearly all cases the stem is profusely branched; the branches may be short and rigid, flexuous, or even scandent. The spines are in all cases reduced branches; not only are all the young branchlets usually spinose tipped, but many species are densely armed with needle-like processes arising in the axils of the leaves.

Leaves.—The leaves in most of the species of *Lycium* are typically xerophytic; they are always alternate, and are borne in fascicles of from one to eight. Three general types may be noted:

1. Large, ovate or variously shaped leaves, thin in texture, with little or no pubescence, and slight cuticular development. This type of leaf is found in the more mesophytic species, such as *L. halimifolium*, *L. glomeratum*, etc.

2. Extremely fleshy leaves, covered with a thick cuticle. This type is found in the xerophytic species, resembling the leaves of *Sedum* in being extremely succulent. Such species as *L. caroliniianum*, *L. Andersonii*, etc., have this type of foliage.

3. Less fleshy leaves, covered with dense pubescence, and often somewhat glandular. This is the most common type of foliage and is present in such species as *L. Cooperi*, *L. Fremontii*, *L. Parishii*, etc.

Pubescence.—The pubescence varies considerably, although the hairs are multicellular in all instances, as shown in text-fig. 1. In many of the South American species, such as *L. chilense* (figs. b–g), the hairs are forked, or even branched to the second or third degree, a type of pubescence which is, however, not common in the species native to the United States and Mexico. A rather

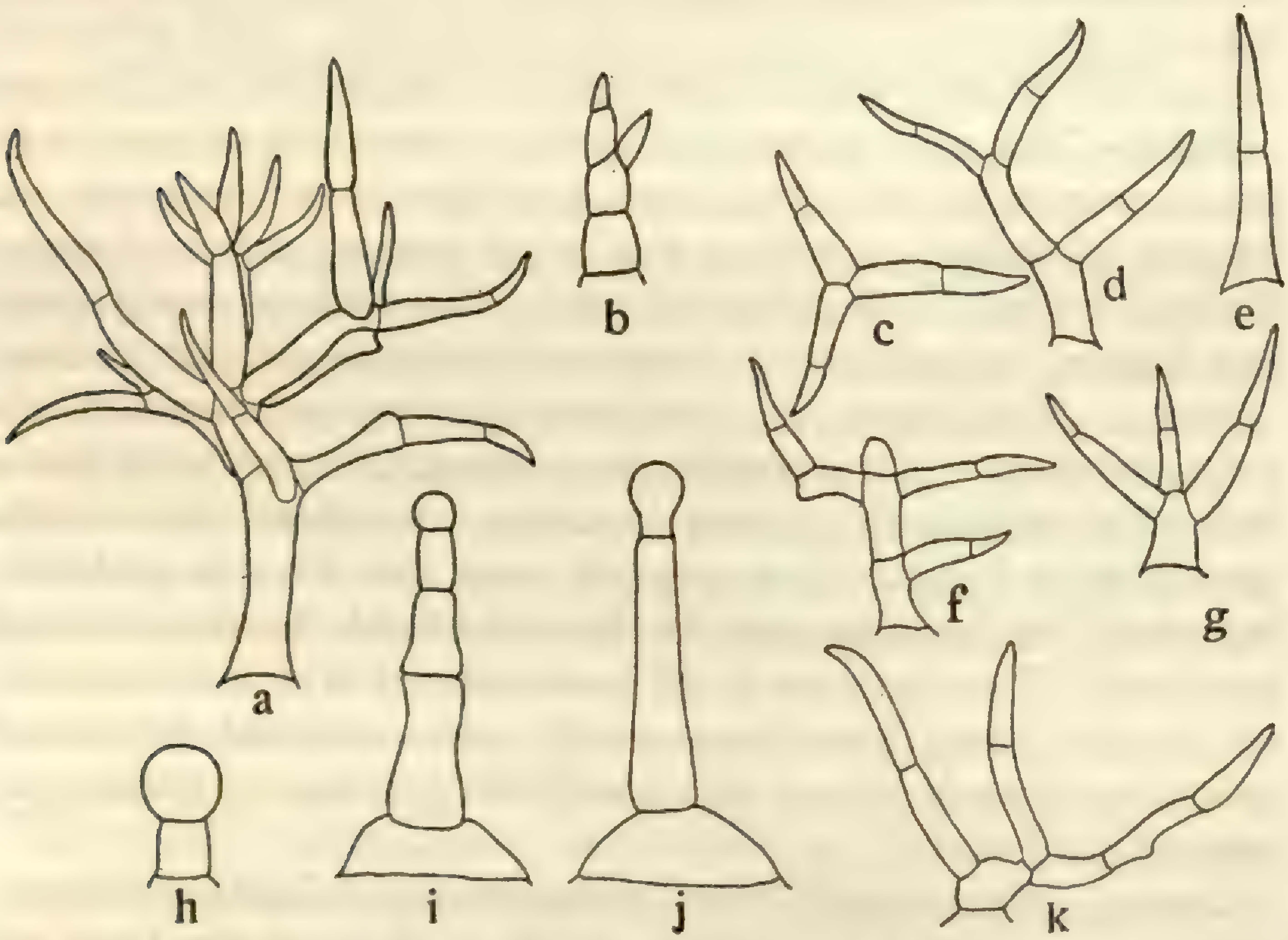

Fig. 1. Types of hairs in various species of *Lycium*: *a*, *cuneatum*; *b–g*, *chilense*; *h*, *Fremontii*; *i*, *Parishii*; *j*, *exsertum*; *k*, *Torreyi*.

common form is that found on *L. Fremontii;* here, as shown in fig. 1h, the leaves and calyx are covered with short stalked glands, giving the plant a viscid appearance. In other species the glands are much longer, as shown in fig. 1i, from the leaf of *L. Parishii*, and in fig. 1j, from the leaf of *L. exsertum*. The margins of the corolla-lobes are usually fringed or ciliate; in some instances, however, they are clothed with longer interlacing, branched hairs,

as shown in fig. 1k, from the corolla-lobe of *L. Torreyi.* In many species the leaves are covered with a mealy excresence, which, according to Solereder, consists primarily of oxalate of lime. In *L. cuneatum* the leaves are densely covered with dendroid hairs as much as one-fourth millimeter long (fig. 1a).

Inflorescence.—The flowers in nearly all species are borne singly or in groups of two to four in the axils of the fasciculate leaves; in *L. Morongii* and *L. glomeratum,* however, the flowers are borne in glomerules of four to twenty at the nodes, much like the flowers of *Acnistus.*

Pedicels.—The length of the pedicel varies greatly within the genus and is of very little diagnostic significance.

Calyx.—The calyx of *Lycium* offers the most valuable morphological characters for a taxonomic treatment of the group, particularly the form, shape, and relative length of the lobes. Dunal based his sections upon these characters, as did most of the workers before him. These characters are not, however, as Miers pointed out, of sufficient value to delimit subgenera or sections. In all cases, the calyx is composed of a tubular portion with four to six lobes of varying length, the length being fairly constant within the species; however, *L. Parishii, L. Richii,* and *L. ciliatum* are notable exceptions. In some species, the tube is many times the length of the lobes, as in *L. Fremontii, L. repens,* and *L. humile,* whereas the other extreme is seen in *L. macrodon* where the lobes are as long as, or much longer than the tube. The calyx is usually split by the growing fruit, but is sometimes slightly accrescent.

Corolla.—The corolla is infundibuliform, obconic, or nearly tubular, commonly actinomorphic, although occasionally slightly zygomorphic; it is always constricted above the ovary and expanded somewhat, though sometimes but slightly, at the throat. It breaks away from the ovary near the base, and usually leaves a ring of tissue surrounding that organ. Because of the difficulty in delimiting the different parts of the tubular portion, "tube, throat, and limb," the writer has considered it best to designate the entire tubular portion of the corolla as "tube," and to give by measurements, the size and proportion of the various parts. The tube is usually glabrous exteriorly, but in some cases, e. g. *L.*

Cooperi, L. chilense, L. distichum, etc., it may have considerable pubescence on the back of the lobes or near the base of the tube, or in both places. It is nearly always pubescent interiorly, near the base of the filaments. The number of lobes varies, the dominant number being four or five, but rarely six or seven lobes occur. They are imbricate in aestivation, and may be rotate, somewhat reflexed, or nearly erect in anthesis; their margins, as previously stated, vary from glabrous to ciliate or lanate-ciliate. The length of the lobes varies greatly in many species, and even on the same individual plant there is sometimes much variation in this respect; in certain species, however, the length of the corolla-lobes is relatively constant and is a good taxonomic character. *Lycium Fremontii, L. Richii, L. Berlandieri*, and *L. Tweedianum* are species in which the length of the lobes is extremely variable; these species would all appear in two of Miers' sections. Because of this fact, it seems decidedly unwise and entirely artificial to try to delimit sections, as Miers did, on the length of the corolla-lobes.

Stamens.—The stamens are borne upon the corolla-tube alternate with the lobes. The point of juncture of the filaments varies with the species, and is of considerable specific value. In *L. verrucosum* they are adnate to the base of the lobes, but in all other species the point of separation lies between one-fifth and four-fifths the way from the base of the corolla-tube. In all but one or two instances, they are pubescent at or near the base. In the section *Selidophora* the base of the filament is enlarged, glandular, and fringed with a row of cilia. In the other species this glandular enlarged portion is lacking, and the base may be glabrous, in which case there is usually a fringe of hairs just above this point; in other species, the entire base of the filament may be pubescent. The filaments vary in length with the species, and they frequently show considerable variation within the species. They may be unequal, subequal, or equal. The pubescence of the filaments and their relative length are characters of taxonomic significance. The anthers are attached to the connective by their inner face from one-third to one-half the way from their base, and are longitudinally dehiscent. The two halves are frequently free from one another except at the tip and the point of juncture with the connective.

Stigma.—The stigma in all cases is enlarged, flattened, and very slightly two-lobed; it is glandular, but not pubescent. The shape and size is quite constant throughout the genus.

Style.—The style is slender, filiform, and several millimeters in length. Although the length varies much within the species, the relative length of the style is an important character which must be taken into consideration.

Ovary and fruit.—The ovary shows extreme variation within the genus, but its characters are quite constant within the species. The common type of ovary is that usually found in the family, that is, a bicarpellary, two-celled ovary which matures into a fleshy berry with a succulent and highly colored, usually red, pericarp. The placentation, as shown in pl. 12, fig. 7, is axile, the ovules being anatropous (pl. 12, fig. 5). The vascular system is interesting; in *L. exsertum*, for example, there are one dorsal and two lateral traces to each carpel. The lateral traces branch first, then the dorsal trace forks; subsequently, each of these strands again branches, so that there are twelve or fourteen separate strands of vascular tissue present at a point slightly below the ovuliferous portion. Next, the laterals again branch, the larger of the two strands moving inward to the placentae. Thus there are present in each carpel two traces which are but partially, if at all, fused, from which the vascular tissue running to the ovules has its origin. This fleshy type of fruit may be replaced by a drier type in which the pericarp becomes more sclerenchymatous, as in *L. cestroides*. *Lycium Cooperi* (pl. 13, fig. 6) has an unusual type of fruit. The upper halves of the carpels have a sclerenchymatous wall and separate readily. Exteriorly, the fruit is somewhat cylindric, with a wedge-shaped apex, the whole being constricted about two-thirds the way from the base. One, sometimes two, seeds are borne in this upper part, and the pericarp is much hardened, a septum nearly dividing this top part from the lower portion. This basal part bears from five to nine seeds, the seeds frequently being somewhat smaller than those in the upper part. The pericarp of the lower chamber is usually much less sclerified than that of the upper, and the carpels do not separate. It is not uncommon to find three carpels developed in this species.

This type of fruit suggests a transition from the true berry to the next type, exemplified by *L. macrodon* (pl. 12, figs. 1–3, and pl. 13, fig. 1) and by *L. puberulum.* In these species, the two carpels are definitely divided into an upper and a lower compartment by a nearly complete, much-hardened septum which is continuous with the endocarp of the ovary-wall, as shown in pl. 12, fig. 1. The upper halves of the fruit are readily separated at maturity; the internal wall of each carpel is much hardened. Each of these compartments contains one or two seeds, which are unusually large. The lower half of the carpel differs in that the pericarp is somewhat fleshy, becoming but little, if at all sclerified. Each half contains several ovules, as shown in pl. 12, fig. 3, which are nearly always abortive, one or two infrequently developing to scarcely half the size of the seeds in the upper compartment. These lower halves of the carpels are not so readily separable as the upper halves. In *L. macrodon* three carpels are very frequently developed.

Lycium californicum and *L. Ameghinoi* present an extreme type in ovule reduction, as shown in pl. 12, figs. 4–6, and pl. 13, figs. 11–15. In these species, the endocarp is much hardened, and the two carpels separate readily at maturity. Each carpel contains one ovule which develops into a rather large seed.

This transitional series is of significance for two reasons: (1) it throws an interesting side-light into the interrelationships of the genus; and (2) it offers a suggestion as to the nature of the disc in the Solanaceae.

To consider first the nature of the disc—in many species of *Lycium* there is present below the ovary a bright red, pulpy mass of tissue which has been called a disc, although its exact morphological nature has never been investigated. From pl. 12, fig. 1, representing a longitudinal section of the ovary of *L. macrodon,* it can readily be seen that in this species, at least, the "disc" is composed of ovary tissue. The ovules which are present in the young ovary in the basal half of the carpel are apparently never fertilized—at least they do not develop into viable seeds, but, on the contrary, are manifest as abortive ovules in the unusually large "disc" of the older and mature fruit. Anatomical investigation of the fruit of other species of *Lycium* has not been made as

yet, so that it is not possible to state with certainty that the disc in the other species is of the same origin as that in *L. macrodon,* but that such is the case, the writer strongly suspects.

As to the relationship indicated by this series—the one-celled, one-seeded carpel of *L. californicum* and *L. Ameghinoi,* pl. 12, figs. 4–6, and pl. 13, figs. 11–15, approaches the fruit of some of the Verbenaceae very closely, on the one hand, whereas it also shows a rather close similarity to the fruit of *Grabowskia* of the Solanaceae (pl. 13, figs. 2–5), as is evidenced by the fact that Spegazzini placed *L. Ameghinoi* in *Grabowskia* because of the fruit characters. In so doing, however, he overlooked the fact that *Grabowskia* always has a two- or more-seeded carpel, the seeds being separated by a median longitudinal dissepiment. It is through *Grabowskia,* however, that the similarity in fruit characters between the Solanaceae and Verbenaceae is most clearly shown. Plate 13, figs. 7–10, represents the fruit of *Citharexylum brachyanthum,* a Verbenaceous genus, which resembles the fruit of *Grabowskia* very closely, the only marked difference between the two being that the embryo is straight in *Citharexylum* and curved in *Grabowskia.*

Seeds.—The shape of the seeds is determined very largely by their number in the carpel; they are usually somewhat flattened and ovate-triangular in outline. The surface is marked with small pittings. The embryo is curved, making nearly a half-turn, sometimes more. The cotyledons are long and slender, and the radicle points toward the basal portion of the seed.

Geographical Distribution

Lycium has an interesting geographical distribution in the New World; there are two centers of dispersal, namely, Arizona and Argentina. Of the fourteen native North American species, ten are found in southern Arizona, ten in northern Mexico, nine in southern California, five in Lower California, five in Texas, four in New Mexico, three in Utah, two in southern Nevada, one in Colorado, and one in the Gulf States. Two species are found in the West Indian Islands, one of them, *L. carolinianum,* occurring on the North American continent also, the other on the mainland of South America. A variety of *L. carolinianum* occurs in the Sandwich Islands.

There are thirty species found in South America; of these, twenty-two are found in Argentina (thirteen being endemic to that country), seven in Chile, four being endemic there, seven occur in Bolivia, four in Paraguay, two in Uruguay, Peru, and Brazil, and one in Colombia, Ecuador, the Galapagos Islands, and Venezuela. Thus it is seen that only eight of the thirty species do not occur in Argentina, whereas only two species are common to both Chile and Argentina.

Most of the species are members of the typical desert flora, but some of them, notably *L. Tweedianum* and *L. carolinianum*, seek brackish tide-lands or overflow land, whereas *L. Morongii* and its allies appear to follow river banks and flood-plains.

Phylogeny

From the evidence presented by a study of the American species, little can be definitely stated regarding the status of the different members of the genus. One fact stands out above the rest, and that is that in most cases the North American species find their closest relationships with South American species rather than with one another.

Considering first the North American species—*L. Richii* and *L. carolinianum* are fairly closely related, and probably find their nearest relative in *L. Tweedianum* of South America, one variety of which, var. *chrysocarpum*, reaches the West Indian Islands. Although *L. pallidum*, *L. puberulum*, *L. macrodon*, and *L. Cooperi* are but distantly related, they form a series which is well set off from the other members of the genus. Their origin is vague, but it is possible that they are closest to *L. Fremontii*, the latter species and *L. exsertum* resembling the South American *L. humile* and *L. repens*. *Lycium californicum* is very similar to *L. Ameghinoi* of southern Argentina; *L. Berlandieri* shows relationship to *L. minimum*, *L. nodosum*, *L. Tweedianum*, and *L. vimineum* of the southern hemisphere. *Lycium Andersonii*, *L. Torreyi*, and *L. Parishii* form an aggregate which finds its counterpart in the austral species *L. fragosum*, *L. minutifolium*, *L. elongatum*, etc.

Of the other South American species not mentioned, *L. cestroides*, *L. Morongii*, *L. cuneatum*, *L. Martii*, *L. cyathiformum*, and *L. glomeratum* show some points of similarity, especially the second,

third, and fourth. *Lycium chilense, L. ciliatum, L. Vergarae,* and *L. Comberi* form another aggregate, and *L. rachidocladum, L. tenuispinosum, L. pubescens,* and *L. ovalilobum* comprise a third, from which it is possible that *L. pubitubum* and *L. decipiens*

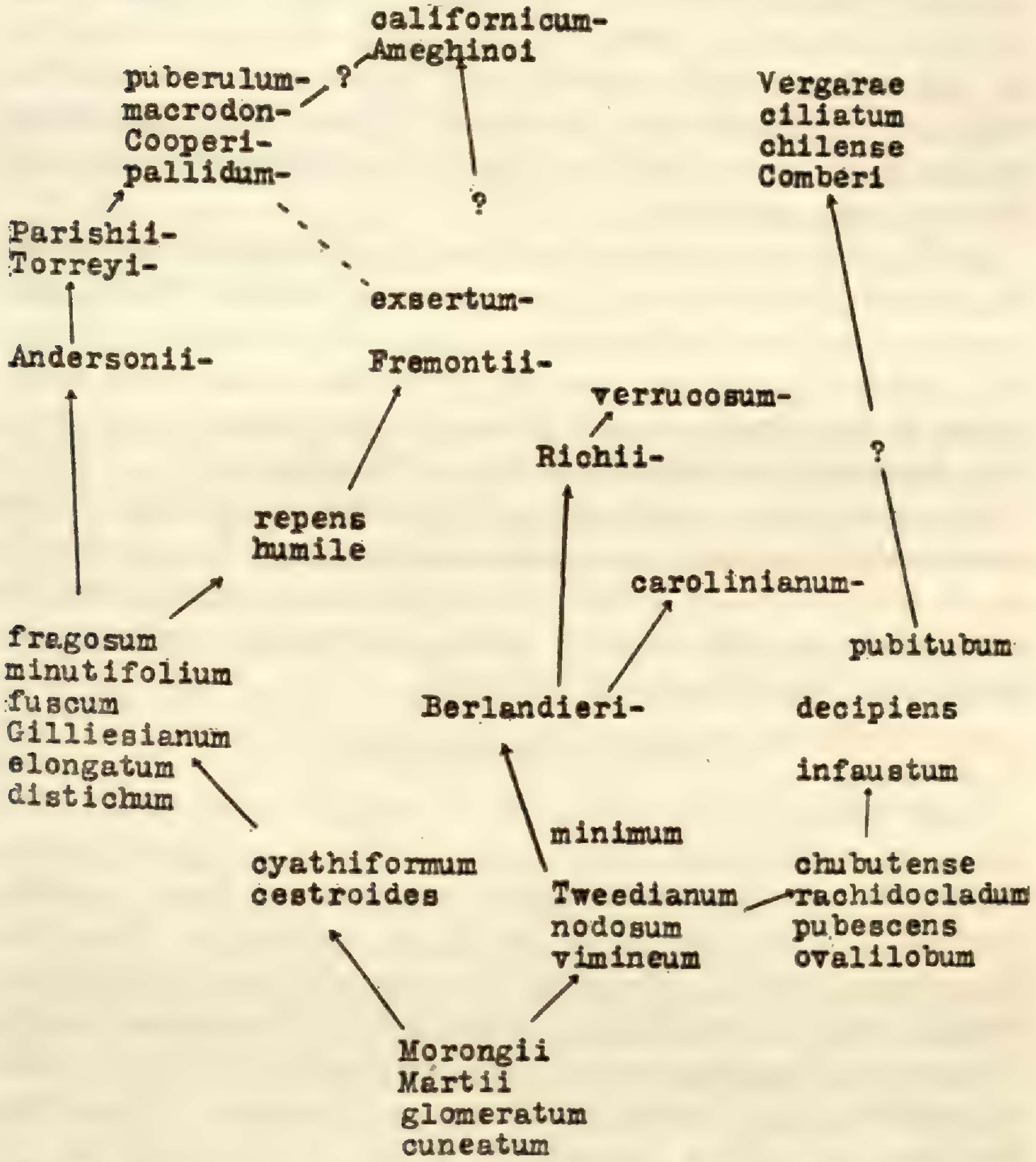

Fig. 2. Chart showing relationships of species of *Lycium*. The species followed by the dash are North American. (For *chubutense* read *tenuispinosum.*)

originated. Although there are thus seen to be several small groups of closely related species, the interrelationships of these groups are much more obscure. Text-figure 2 shows the situation more graphically.

The writer has assumed that *L. puberulum* and *L. macrodon* are the culmination of the line of advance of those species which have long tubular corollas, whereas *L. Ameghinoi* and *L. californicum* are the end of another line, a parallel series of forms having shorter corollas and longer lobes. It might be argued that *L. californicum* and *L. Ameghinoi* are closely related to *L. macrodon* and were probably derived from that species by a further reduction of fertile tissue of the carpel. There is this possibility, but the plants are so totally unlike in all other respects that this does not seem probable.

South America, northern Argentina in particular, is held to be the place of probable origin of the species in the New World, and it seems altogether possible that the genus itself originated there. It is rational to suppose that the primitive species were quite similar to those in the present genus *Acnistus*, being mesophytic, with clustered flowers much like those of *L. Morongii*.

Any attempt at an explanation of the world-distribution of the genus could be no more than guesswork; the genus is undoubtedly an old one, and much would have to be known concerning the fossil history in order to arrive at any conclusions concerning its spread over the arid parts of the world.

Specific Delimitation

In general, there is a wide range of variation within the species of *Lycium*, such characters as the relative length of the calyx and corolla-lobes holding remarkably constant in some species, whereas in others they show almost no uniformity. The fact that some groups (*L. Fremontii*, for example) are definitely dimorphic, adds to the difficulty of specific delimitation and makes it imperative that abundant material be studied in detail in order to ascertain what characters, if any, are constant. The writer has been particularly fortunate in having this material for all the North American species, and, to a lesser degree, for some of the South American species. The study of complete series of seasonal and ecological variations has made it possible to divide the genus into a relatively few large aggregates having well-marked geographical distribution in most instances, and resembling one another with a fair degree of constancy in most mor-

phological characters, but usually varying within the group in others. These aggregates constitute the species. Within the species it has frequently been found possible to delimit lesser groups also having distinctive geographic distribution, such units usually differing from each other and from the species in but one or two somewhat minor particulars, yet holding constant within the unit itself. They have been set off as varieties or forms. In thus delimiting the species of North America, it has been necessary to reduce the total number of described species very considerably.

The same procedure has been followed with the South American species in so far as the amount of material warranted. In the case of *L. chilense*, where there were perhaps one-third as many collections available as for all the other species of the southern hemisphere combined, it has been possible to work along such lines, as the list of synonyms under that name can testify. It seems certain that *L. chilense* is not only a wide ranging plant, but that there is here an unusual amount of variation in the leaf-size and leaf-shape—the various forms having been described previously as new species or new varieties.

With those species represented by few collections, however, the writer has deemed it advisable to be more conservative in his reductions, so that, where it cannot be shown that two or more forms can be linked by a series of specimens (in other words, where it cannot be shown that the variation is continuous) all species concerned have been conserved; where it seems to the writer that the species may be too closely related to be valid, and that lack of material, alone, keeps such proof obscure, opinions to this effect have been recorded under the discussion of the species in question. Thus, although the goal striven for is the maintenance of the same fundamental criteria for specific delimitation throughout the genus, the writer suspects that in those instances indicated, the species may prove to be of lesser value in the face of added evidence.

Evidence of Hybridization

Although there is no experimental evidence to offer for the prevalence of hybridity in the genus, it seems certain that in at least four or five instances material of hybrid nature has been

collected. Hieronymus[30] recorded the occurrence of what he took to be a hybrid between *L. cestroides* and *L. argentinum* (*L. ciliatum*) in 1876, and in 1881[30] he reported a hybrid between *L. cestroides* and *L. elongatum.* As his discussion and figures show, these plants are almost exact intermediates between the species concerned.

Among the North American species, it would appear that *L. Andersonii* and *L. Torreyi* may occasionally hybridize where the ranges of the two species overlap—in the Coachella Valley of southern California and in Arizona and southern Utah. Throughout its range *L. Torreyi* has white-fringed corolla-lobes, and a more thick, but proportionately shorter, corolla-tube than *L. Andersonii*, the latter species having but sparsely ciliate corolla-lobes. However, where the two species occur together, forms have been collected having the slender corolla-tube and leaves of *L. Andersonii* but with the lobes of the corolla being lanate as in *L. Torreyi*, the habit of the plant being more like that of *L. Torreyi.* Similarly, at least one instance has been noted where *L. Richii* has apparently hybridized with *L. Torreyi;* this plant was collected in the Coachella Valley, the only region where the two species overlap in range.

Besides these more striking instances, it seems not unlikely that many of the intermediates may be due to this cause, a fact which, if substantiated, would tend to explain much of the variation within such species as *L. chilense* and *L. Fremontii.* In view of the ease with which other genera of the Solanaceae hybridize, it would be but expected to find considerable germinal compatibility between the members of this genus.

Generic Relationships

Miers[31] pointed out the fact that, if the species of *Lycium* described up to that time were all preserved in one genus, it would necessitate making the generic limitations so broad that several other genera would have to be merged with it, namely, *Acnistus, Salpichroa, Iochroma,* and *Chaenesthes* (the latter a new genus

[30] Hieronymus, Bol. Acad. Nac. Cienc. Cord. **2**: 43. *pl. 2, figs. 1–8.* 1876; *op. cit.* **4**[1]: 1. *figs. 1–16.* 1881.

[31] Miers, Hook. Lond. Jour. Bot. **4**: 330. 1845.

which he proposed at that time). In order to avoid this difficulty he restricted the genus *Acnistus* to those species which are spineless trees or shrubs with umbellate or glomerate fascicles of flowers, with large leaves, and valvate-induplicate aestivation; they formed part of the sections called *Anisodontia* by G. Don and *Lyciothamnos* by Endlicher. He restricted the name *Lycium* to "those shrubs, mostly with small fasciculate leaves, whose branches terminate in spines that have only 1 or 2 flowers in each axil," and imbricate aestivation. He then proposed two new genera, one of them, *Chaenesthes,* to include several species that had previously been placed in *Lycium,* "trees or large shrubs, . . . having generally long crimson or orange colored flowers, . . . the corolla presenting a 5-lobed border, with 5 small teeth in the intermediate narrow plicatures, as in *Dunalia.*" The other genus, *Lycioplesium,* with valvate-plicate aestivation—corolla-lobes acute with pubescent margins, spiny shrubs, with 1 or 2 flowers growing out of the fascicles of small fleshy leaves, "corolla—usually broader and more tubular than in *Acnistus* or *Lycium,*" resembling *Dunalia,* but without intermediate lobes in the corolla. However, in 1848[32] he realized that his genus *Chaenesthes* was not generically distinct from *Iochroma* and reduced it to a section under that genus.

Dunal[33] accepted Miers' disposition of these genera; but Bentham and Hooker[34] reduced his *Lycioplesium* to *Acnistus,* pointing out the fact that Miers had combined species of several genera under his new genus; they also treated his *Chaenesthes* under *Iochroma. Lycium* and *Grabowskia* were included in tribe II, *Atropeae,* with imbricate aestivation; *Acnistus, Dunalia,* and *Iochroma* under Tribe I, *Solaneae,* with plicate, valvate, or induplicate aestivation.

Wettstein[35] made the same disposition of Miers' *Chaenesthes* and *Lycioplesium* that Bentham and Hooker made; however, he placed all the genera in the same tribe, *Solaneae-Lycineae, Lycium* and *Dunalia* being separated from *Acnistus* and *Jochroma* (*Iochroma*) by the characters "flowers single, rarely fascicled," as

[32] Miers, Hook. Lond. Jour. Bot. **7**: 343. 1848.
[33] Dunal in De Candolle, Prodr. **13**^{1}: 3. 1852.
[34] Bentham and Hooker, Gen. Pl. **2**^{2}: 882. 1876.
[35] Wettstein in Engl. & Prantl, Nat. Pflanzenfam. **4**^{3b}: 10. 1891.

opposed to "flowers 2 or fascicled, rarely single." *Acnistus* was separated from *Jochroma* on the ground that its calyx did not enlarge in fruit. Because of the fact that there is considerable variation in the number of flowers in the fascicle, this treatment of these closely related genera seems unsatisfactory, and the author considers the treatment of Bentham and Hooker to be the more correct one. Although, as yet, it has not been possible to see representative material of many of the species of *Acnistus* and *Iochroma*, yet in those species of *Acnistus* which have been seen the corolla is certainly valvate-induplicate, whereas that of *Lycium* is invariably imbricate.

Macbride[36] combined under *Dunalia*, several of the species which had previously been transferred back and forth between *Lycium* and *Acnistus*. His contention was that the basal appendages of *Dunalia* become so reduced in some species that the genus grades into *Acnistus*. He also pointed out that the glomerate inflorescence of *Acnistus* is not distinctive. From his descriptions, it seems possible that one or two of his species may belong to *Iochroma;* therefore, it seems to the writer that, until such a time as it is possible for a monographer to make a thorough study of these closely related genera, it is best to restrict those species with basal filament appendages to *Dunalia*, and to include the closely related species in *Iochroma* or *Acnistus* according to their other morphological characters. These five genera may be separated tentatively, as follows:

A. Filaments without scales or appendages at base.
- B. Corolla imbricate.
  - C. Ovary of two, 2-seeded carpels, each carpel with a median longitudinal dissepiment, one seed in each cavity; flowers several in a reduced panicle or cyme (sometimes only 2 or 3).......... *Grabowskia*
  - CC. Ovary of two, 1–many-seeded carpels, carpels not divided as above; flowers 1–several in the axils of the leaves.................... *Lycium*
- BB. Corolla valvate-induplicate or plicate.
  - C. Corolla long-tubular, or narrowly tubular-infundibuliform, sometimes slightly inflated, lobes small, rounded, sometimes with small intermediate teeth; calyx enlarging somewhat in fruit; flowers borne in 2's or 3's, sometimes in glomerules.................. *Iochroma*
  - CC. Corolla infundibuliform, with 5 ovate-acute or rounded lobes; calyx not enlarging in fruit; flowers borne in dense glomerules at the nodes, less commonly, few at the nodes.................. *Acnistus*

AA. Filaments with scales or lateral appendages at base.............. *Dunalia*

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[36] Macbride, Field Mus. Publ. Bot. 8^2: 107. 1930.

Taxonomy

Lycium Linn. Sp. Pl. **1**: 191. 1753; Gen. Pl. ed. 5, 88, no. 232. 1754; Kunth, Syn. Pl. **2**: 179. 1823; G. Don, Gen. Hist. Dichl. Pl. **4**: 457. 1838; Raf. Syl. Tell. 52, no. 261. 1838; Endl. Gen. Pl. 667, no. 3863. 1841; Walp. Rep. Bot. Syst. **3**: 106. 1844; Martius, Fl. Brasil. **10**: 153. 1846; Remy in Gay, Hist. Chil. Bot. **5**: 91. 1849; Dunal in DC. Prodr. **13**^{1}: 508. 1852; Miers, Ann. & Mag. Nat. Hist. II, **14**: 7. 1854, and Ill. S. Amer. Pl. **2**: 94. 1857; Weddell, Chlor. And. **2**: 108. 1857; Benth. & Hook. Gen. Pl. **2**^{2}: 900. 1876; Gray, Bot. Calif. **1**: 542. 1876; Hemsley, Biol. Cent.-Am. Bot. **2**: 425. 1882; Gray, Syn. Fl. N. Amer. **2**^{1}: 237. 1886; Wettstein in Engl. & Prantl, Nat. Pflanzenfam. **4**^{3b}: 13. 1891; Small, Fl. S. E. United States, 992. 1903; Reiche, Anal. Univ. Chil. **123**: 392. 1908; Rob. & Fern. Gray's Man. Bot. ed. 7, 716. 1908; Reiche, Fl. Chil. **5**: 312. 1910; Woot. & Standl. Contr. U. S. Nat. Herb. (Fl. N. Mex.) **19**: 568. 1915; Abrams, Fl. Los Angeles & Vic. 323. 1917; Rydb. Fl. Rocky Mts. 758. 1917; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1285. 1924; Jepson, Man. Fl. Pl. Calif. 889. 1925.

Jasminoides Medicus, Phil. Bot. **1**: 134. 1789.

Johnsonia Necker, Elem. Bot. ed. 2, **2**: 49. 1808.

Oplukion Raf. Syl. Tell. 53, no. 266. 1838.

Teremis Raf. *l. c.* no. 271.

Evoista Raf. *l. c.* no. 289.

Lycioplesium Miers, Hook. Lond. Jour. Bot. **4**: 330. 1845, in small part.

Acnistus Miers, *l. c.* 335, in small part.

Grabowskia Spegazzini, Anal. Soc. Cient. Argent. (Nov. Add. Fl. Patag.) **53**: 166. 1902, in part.

Suffrutescent to fruticose, erect or spreading, shrubs or small trees, glabrous or pubescent, usually armed. Leaves alternate, commonly fasciculate, inner ones reduced, succulent or not succulent, entire or very minutely toothed, mealy, glabrate, or with multicellular, simple or forked hairs, frequently glandular. Flowers borne singly or in 2's–4's, rarely glomerate in leaf-axils, pedicels short, frequently reflexed. Calyx campanulate to tubular, ruptured by growing fruit, sometimes slightly accrescent, 4–6-lobed, lobes short-triangular to linear or ovate. Corolla whitish

to lavender or greenish-purple, obconic-tubular to infundibuliform or narrowly campanulate, actinomorphic or very slightly zygomorphic; limb commonly expanded somewhat; lobes 4–7, imbricate in aestivation, varying in length from longer than the tubular portion of corolla[37] to less than $\frac{1}{10}$ its length, their margins commonly ciliate to lanate; corolla-tube usually glabrous externally, less frequently with considerable pubescence, commonly hairy within near base of filaments; stamens 4–6, filaments filiform, subequal to decidedly unequal, their base pubescent, glandular or glabrous, adnate to tubular portion of corolla. Anthers oval, thecae longitudinally dehiscent, affixed to connective near their middle. Stigma shortly 2-lobed, green. Style long and slender. Ovary bicarpellary, 2-celled, 2–many-seeded, fleshy to dry and sclerenchymatous, surrounded at base by a fleshy, often inconspicuous, disc. Seeds irregular in shape, minutely pitted. Embryo coiled, cotyledons long and slender.

Type species: *L. afrum* Linn. Sp. Pl. **1**: 191. 1753.

SECTIONS

As was shown in the discussion of the morphology, the sections which have been made previously in the genus have all been based on very artificial and variable characters, so that it is not only impossible to place a given species in the section to which it belongs, but many of the species will key to more than one section. On ovary characters, *L. californicum* and *L. Ameghinoi* stand well apart from the rest of the genus because of the one-seeded, sclerenchymatous carpels. However, *L. puberulum* and *L. macrodon* have carpels approaching this condition, and *L. Cooperi* has a fruit resembling that of *L. macrodon.* Therefore, it would be possible (1) to delimit four sections on the character of the ovary, (2) to combine all the species into one section, or (3) to put *L. californicum* and *L. Ameghinoi* into a separate section, and to keep *L. macrodon, L. Cooperi,* and *L. puberulum* with the species of *Eulycium.* Because of the fact that the latter species are very similar to such species as *L. Fremontii* and *L. exsertum* in corolla characters, this disposition seems the most judicious method to pursue.

[37] In this paper, the term "tubular portion of corolla" is used to designate the "tube," "throat," and "limb" collectively. In this way the writer believes that much ambiguity may be avoided.

The group consisting of *L. chilense*, *L. ciliatum*, *L. Vergarae*, and *L. Comberi* forms another natural section characterized by enlarged glandular-based filaments, the glandular surface being surrounded by a fringe of cilia. In all the other members of the genus this enlargement is lacking and the pubescence is not confined to a fringe-like border.

Key to Sections

A. Filaments enlarged and glandular just above the point of attachment, this enlargement bordered with cilia; corolla usually pubescent exteriorly near the base............Section II. *Selidophora*[38] n. sect. (p. 312)

AA. Filaments neither enlarged nor glandular, usually covered with hairs at or near the base; corolla seldom pubescent exteriorly near the base.

B. Carpels 1-ovuled; fruit 2-seeded..Section III. *Sclerocarpellum* n. sect. (p. 325)

BB. Carpels 2–many-ovuled; fruit 2–many-seeded, but if only 2-seeded, then with abortive ovules...........Section I. *Eulycium* G. Don (p. 206)

Key to Species of Sections Eulycium and Sclerocarpellum

A. Flowers numerous, borne in glomerules at the nodes; tree-like forms with leaves[39] 1–8 cm. long, 0.8–3 cm. broad.

B. Tubular portion of corolla 4.5 mm. or more long, persistent-pubescent exteriorly..*5. L. glomeratum*

BB. Tubular portion of corolla 4.5 mm. or less long, glabrate exteriorly.

C. Calyx usually broader than long; filaments adnate to about 1 mm. above base of corolla-tube; plants of northeastern Brazil..*4. L. Martii*

CC. Calyx usually not broader than long; filaments adnate to point somewhat more than 1 mm. from base of corolla-tube; plants of Bolivia, Paraguay and northern Argentina.

D. Leaves densely and persistently floccose-lanate; corolla-tube 1.25–1.75 mm. in diameter above ovary; calyx 1.5–2 mm. long. ....*3. L. cuneatum*

DD. Leaves glabrate; corolla-tube about 1 mm. in diameter above ovary; calyx 1.5–2.5 mm. long.

E. Leaves 3–6 cm. long.........................*2. L. Morongii*

EE. Leaves 1–2 cm. long..........*2a. L. Morongii* forma *parvifolium*

AA. Flowers few, 1–3 at the nodes (sometimes more); leaves seldom over 1 cm. wide (except *L. cestroides* and *L. cyathiformum*).

B. Calyx-lobes from ⅔ as long to as long or longer than tubular portion, or if not ⅔ as long as tube, at least 2 mm. long, calyx cleft equally, never somewhat 2-lipped, therefore the lobes about equal in length.

C. Corolla-lobes not over ⅓ as long as tubular portion, usually much less.

[38] *Celidophora* of Miers, Ann. & Mag. Nat. Hist. II, **14**: 339. 1854.

[39] Because of the fact that the leaves of some species of *Lycium* are extremely succulent, they shrink greatly in diameter when dried. The measurements of leaf size given in this key apply to dried material only.

D. Plants of North America.
E. Filaments attached at summit of tubular portion of corolla. ....22. *L. verrucosum*
EE. Filaments attached near middle of corolla-tube, or below.
F. Leaves glaucous-green; corolla-tube 4 mm. or more in diameter at summit.
G. Ovary 20–50-seeded..........................*36. L. pallidum*
GG. Ovary 4–8-seeded.........*36a. L. pallidum* var. *oligospermum*
FF. Leaves not glaucous-green; corolla-tube less than 4 mm. in diameter at summit.
G. Fruit 2–4-seeded, with 1 or 2 fertile seeds in the top of each carpel, and abortive ovules in compartment below.
H. Calyx-lobes narrowly linear..............*38. L. macrodon*
HH. Calyx-lobes oblong-ovate, not linear......*39. L. puberulum*
GG. Fruit not as above, with more than four seeds.
H. Corolla nearly tubular; ovary with hardened pericarp, with constriction near summit..............*37. L. Cooperi*
HH. Corolla more nearly infundibuliform; ovary a fleshy, globose or ovoid, several-seeded berry.
I. Corolla-lobes ⅓ as long as tube, usually 4 (5); filaments densely pilose at base; calyx glabrous to sparsely pubescent.
J. Calyx-lobes usually shorter than the tube; plants of the mainland of southern California, Baja California, and Mexico................*21. L. Richii*
JJ. Calyx-lobes usually longer than the tube; plants chiefly of the islands off the coast of southern California................*21a. L. Richii* var. *Hassei*
II. Corolla-lobes ¼–⅓ as long as tube, 5; filaments sparingly pilose at base; calyx densely pubescent.... ....*31. L. Parishii*
DD. Plants of South America.
E. Corolla glabrate, exteriorly, near base, but lobes usually sparingly ciliate.
F. Tube of corolla 13–18 mm. long.
G. Style exserted 2–4 mm.
H. Plants densely pubescent; corolla pubescent exteriorly. ....*27a. L. Gilliesianum* var. *longitubum*
HH. Plants sparsely pubescent; corolla glabrate exteriorly. .... *27. L. Gilliesianum*
GG. Style not exserted over 2 mm..................*28. L. fuscum*
FF. Tube of corolla less than 13 mm. long.
G. Filaments adnate to above center of corolla-tube. .*23. L. elongatum*
GG. Filaments adnate to below center of corolla-tube.
H. Corolla-tube 11–12 mm. long..............*26. L. fragosum*
HH. Corolla-tube less than 10 mm. long..........*17. L. decipiens*
EE. Corolla pubescent exteriorly near base.
F. Corolla-tube 10–14 mm. long.
G. Style exserted 2–4 mm.; plants of Argentina........... ....*27a. L. Gilliesianum* var. *longitubum*

GG. Style not exserted so much as 2 mm.; plants of Peru and Chile . . . . *25. L. distichum*
FF. Corolla-tube less than 10 mm. long . . . . *23. L. elongatum*
CC. Corolla-lobes more than ⅓ as long as tube.
D. North American (including W. Indies) and Pacific Island species.
E. Corolla-lobes as long as or longer than tube.
F. Leaves 1–2.5 cm. long, seldom over 2 mm. broad, 3–10 in a fascicle; plants of the region east of the Mississippi River and of the West Indian Islands . . . . *19. L. carolinianum*
FF. Leaves 1.5–3.5 cm. long, 2–5 mm. broad, 1–5 in a fascicle; plants of the region of the Mississippi westward and southward in Mexico, and from the Hawaiian Islands.
G. Plants scarcely spinose; flowers 6–9 mm. long.
H. Filaments sparsely pubescent at base; plants of the Hawaiian Islands . . . . . *19c. L. carolinianum* var. *sandwicense*
HH. Filaments densely pubescent at base; plants of Yucatan, Mexico . . . . *19b. L. carolinianum* var. *Gaumeri*
GG. Plants usually spinose; flowers about 1 cm. long . . . . *19a. L. carolinianum* var. *quadrifidum*
EE. Corolla-lobes shorter than tube (sometimes nearly equal to it).
F. Plants of the Galapagos Islands . . . . *11. L. minimum*
FF. Plants of North America . . . . *21. L. Richii* and var.
DD. South American mainland species.
E. Corolla-tube 6 mm. or more long.
F. Calyx-lobes oblong-ovate, rarely lanceolate; leaves 2–6 mm. broad, minutely glandular-pubescent . . . . *15. L. ovalilobum*
FF. Calyx-lobes lanceolate; leaves 1–3 mm. broad, densely tawny-pubescent.
G. Leaves 4–10 mm. long, 1 (2) mm. broad; calyx clothed with small glandular hairs interspersed with much longer flaccid hairs . . . . *14. L. tenuispinosum*
GG. Leaves 5–12 mm. long, 2–3 mm. broad; calyx uniformly glandular-pubescent.
H. Corolla-tube 6 mm. long, the lobes 3.5 mm. long. . . . . *14a. L. tenuispinosum* var. *Friesii*
HH. Corolla-tube 7–8 mm. long, the lobes 4 mm. long. . . . . *14b. L. Venturii*
EE. Corolla-tube 6 mm. or less long.
F. Filaments attached at or above middle of corolla-tube, pilose at base; leaves 2–4 mm. broad . . . . *13. L. rachidocladum*
FF. Filaments attached below middle of corolla-tube, glabrous at base, but pilose above; leaves 0.5 mm. broad . . *12. L. pubescens*
BB. Calyx-lobes less than ⅔ as long as tube, usually less than 2 mm. long, frequently irregularly cleft, and more or less 2-lipped.
C. Corolla-lobes shortly but densely white-lanate-ciliate, pubescence usually visible to the unaided eye as a white fringe.
D. South American species.
E. Corolla-tube 12–18 mm. long . . . . *6. L. cestroides*
EE. Corolla-tube 10 mm. or less long . . . . *7. L. cyathiformum*

DD. North American species .... *30. L. Torreyi*

CC. Corolla-lobes smooth or ciliate, not densely lanate-ciliate, pubescence usually not visible to the unaided eye.

D. Ovary 2-ovuled; fruit 2-seeded (section Sclerocarpellum).

E. North American species; lobes of corolla nearly equal to tube. .... *45. L. californicum*

EE. South American species; lobes of corolla ⅙–⅓ as long as the tube .... *44. L. Ameghinoi*

DD. Ovary several- to many-ovuled; fruit 2–many-seeded.

E. North American species.

F. Corolla-lobes less than ⅓ as long as tube.

G. Filaments adnate to the top of the corolla-tube. *22. L. verrucosum*

GG. Filaments adnate to the lower ⅔ of the corolla-tube.

H. Leaves 3 mm. or more broad.

I. Stamens exserted 2–3 mm .... *35. L. exsertum*

II. Stamens usually exserted less than 2 mm.

J. Plants usually pubescent, rarely glabrate.

K. Calyx-tube 2–5 mm. long; lobes seldom over ⅓ length of tube.

L. Calyx 3–8 mm. long.

M. Leaves 10–25 mm. long, 3–6 mm. broad. .... *34. L. Fremontii*

MM. Leaves 15–30 mm. long, 7–15 mm. broad. .... *34a. L. Fremontii* var. *congestum*

LL. Calyx 4 (6) mm. or less long .... *35. L. exsertum*

KK. Calyx-tube 1.5–2.5 mm. long; lobes ⅓ length of tube or longer .... *31. L. Parishii*

JJ. Plants scurfy, glabrate . . *29a. L. Andersonii* var. *Wrightii*

HH. Leaves 3 mm. or less broad.

I. Style exserted 4–7 mm . . . . *20b. L. Berlandieri* var. *longistylum*

II. Style exserted less than 4 mm.

J. Corolla, including lobes, 6–8 mm. long, 2–4 times as wide at top as at base (except in *L. Berlandieri* var. *brevilobum*); young branches not spinose.

K. Corolla-lobes about 1 mm. long; tube 4–5 mm. long, little wider at top than at bottom .... *20d. L. Berlandieri* var. *brevilobum*

KK. Corolla-lobes over 1 mm. long; tube 4–6 mm. long, much wider at top than at bottom.

L. Stamens exserted less than 2 mm.; corolla-lobes not more than ⅓ length of tube.

M. Flowers 6–8 mm. long .... *20. L. Berlandieri*

MM. Flowers 4–6 (8) mm. long. .... *20a. L. Berlandieri* f. *parviflorum*

LL. Stamens exserted over 2 mm.; corolla-lobes ⅓ length of tube or more .... *20c. L. Berlandieri* var. *peninsulare*

JJ. Corolla, including lobes, 5–16.5 mm. long, slender, not over 2½ times as wide at top as at base; young branches usually spinose.

K. Leaves glabrous or nearly so; calyx irregularly lobed, sparsely pubescent or glabrate.

L. Flowers usually 4-merous, corolla-tube 4–7 mm. long .... *29a. L. Andersonii* var. *Wrightii*

LL. Flowers usually 5-merous, corolla-tube 7–14 mm. long.

M. Leaves 20–35 mm. long; plants of the Colorado Desert of southern California, and adjacent Arizona. .... *29b. L. Andersonii* f. *deserticola*

MM. Leaves 3–15 mm. long; plants of southwestern United States and northwestern Mexico .... *29. L. Andersonii*

KK. Leaves densely pubescent; calyx regularly lobed and persistently pubescent............ *31. L. Parishii*

FF. Corolla-lobes at least ⅓ as long as the tube.

G. Calyx tubular, 3–6 mm. long; lobes not over 1 mm. long. .... *34. L. Fremontii* and var.

GG. Calyx cup-shaped, 2–4 mm. long; lobes varying in length.

H. Corolla 4-lobed; lobes equal to or longer than tube. .... *19. L. carolinianum* and vars.

HH. Corolla 5-lobed, or, if 4-lobed, the lobes not equal to the tube.

I. Cultivated species, frequently established in nature; leaves glabrate, at least some of them over 10 mm. wide .... *1. L. halimifolium*

II. Native species; leaves less than 10 mm. wide, or if over 10 mm. wide, then densely pubescent.

J. Plants of the West Indian Islands and South America.

K. Calyx 2.5–4 mm. long; corolla-tube 4.5–6.5 mm. long.......................... *10. L. Tweedianum*

KK. Calyx 1–2 mm. long; corolla-tube 4–5 mm. long.......... *10a. L. Tweedianum* var. *chrysocarpum*

JJ. Plants of the mainland of North America, and islands off California.

K. Corolla, including lobes, 7–15 mm. long; leaves spatulate, fleshy, 3–10 mm. broad.*21. L. Richii* and var.

KK. Corolla, including lobes, 6–8 mm. long; leaves linear to elliptic-spatulate, 1–2.5 mm. broad.... .... *20. L. Berlandieri* and vars.

EE. South American (including Galapagos Islands) species.

F. Dwarf plants, spineless, seldom more than 15 cm. tall.

G. Filaments and interior of corolla-tube glabrous.... *33. L. repens*

GG. Filaments and interior of corolla-tube with some pubescence.. *32. L. humile*

FF. Shrubs, upright or spreading, over 15 cm. tall, usually spinose.

G. Corolla-tube 13–18 mm. long.

H. Leaves obovate, 4–6 mm. broad; style equal to corolla-tube or slightly exserted.................... *28. L. fuscum*

HH. Leaves linear-spatulate, 1–3 mm. broad; style exserted 2–4 mm. .... *27. L. Gilliesianum* and **var.**

GG. Corolla-tube less than 13 mm. long.

H. Corolla-lobes less than ¼ length of tubular portion.

I. Filaments adnate to the corolla-tube for more than half its length; calyx 3–5 mm. long, lobes very slender; corolla 5-lobed .... *23. L. elongatum*

II. Filaments adnate to the corolla-tube for less than half its length; calyx seldom over 3 mm. long, lobes broad; corolla 4-lobed.

J. Corolla pubescent exteriorly near base; plants of southern Argentina .... *18. L. pubitubum*

JJ. Corolla glabrous exteriorly; plants of Chile, probably ranging northward to southern Peru.

K. Stamens and style 1–2 mm. shorter than corolla-tube .... *26. L. fragosum*

KK. Stamens and style equal to or longer than corolla-tube .... *24. L. minutifolium*

HH. Corolla-lobes at least ¼ length of tubular portion.

I. Plants of the Galapagos Islands .... *11. L. minimum*

II. Plants of the mainland or West Indian Islands.

J. Calyx 1–1.5 (2) mm. long .... *9. L. nodosum*

JJ. Calyx 2 mm. or more long.

K. Corolla-lobes 2–2.5 mm. long, tube 4–5 mm. long; filaments not adnate to middle of corolla-tube .... *8. L. vimineum*

KK. Corolla-lobes 2.5–4 mm. long, tube 4.5–7 mm. long; filaments adnate to middle of corolla-tube or above.

L. Leaves 0.5–1 (4) mm. broad; corolla-lobes less than twice as long as broad; plants of central Argentina .... *16. L. infaustum*

LL. Leaves 2–15 mm. broad; corolla-lobes 2–3 times as long as broad; plants of the West Indies, Venezuela to northern Argentina. .... *10. L. Tweedianum* and var.

Section I. Eulycium G. Don

Section Eulycium G. Don, Gen. Hist. Dichl. Pl. **4**: 458. 1838, char. emend.; Endl. Gen. Pl. 667. 1841; Dunal in DC. Prodr. **13**[1]: 509. 1852.

Isodontia G. Don, *l. c.* 459, in large part.

Anisodontia G. Don, *l. c.* 460, in large part.

Lyciobatos Endl. *l. c.*; Dunal, *l. c.* 523.

Amblymeris Dunal, *l. c.* 521, in large part.

Brachycope Miers, Ann. & Mag. Nat. Hist. II, **14**: 7. 1854.

Mesocope Miers, *l. c.* 182.

Macrocope Miers, *l. c.* 336, in large part.

Carpels 2–many-ovuled. Fruit 2–many-seeded, if 2-seeded, with abortive ovules below. Filaments glabrous or pilose at base, but not with enlarged, fringed, glandular portion.

1. **L. halimifolium** Mill. Gard. Dict. ed. 8. 1768; Rob. & Fern. Gray's Man. Bot. ed. 7, 716. 1908; Woot. & Standl. Contr. U. S. Nat. Herb. (Fl. N. Mex.) **19**: 569. 1915; Bailey, Cycl. Hort. **4**: 1930. 1916; Tidestrom, Contr. U. S. Nat. Herb. (Fl. Utah & Nev.) **25**: 471. 1925. Pl. 15, figs. 27–29.

L. barbarum L. var. *vulgare* Aiton, Hort. Kew. **1**: 257. 1789.

L. vulgare (Ait.) Dunal in DC. Prodr. **13**[1]: 509. 1852; Miers, Ann. & Mag. Nat. Hist. II, **14**: 185. 1854, and Ill. S. Amer. Pl. **2**: 120, *pl. 70B.* 1857; Gray, Man. Bot. ed. 5, 382. 1868, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 237. 1886; Britton, Man. N. U. S. & Can. 816. 1901; Small, Fl. S. E. United States, 992. 1903; Rydb. Fl. Rocky Mts. 758. 1917.

L. vulgare α normale Terrac. Malpighia **4**: 511. 1891, in part.

A sparingly branched, spreading to recumbent or climbing shrub 1–6 m. tall; branches with slender, sharp spines about 1 cm. long, or spineless, glabrous, silvery-tan; leaves ovate, ovate-lanceolate, elliptic, or rarely spatulate, 2–6 cm. long, 0.5–2.5 cm. broad, attenuate at base to a distinct petiole 3–10 mm. long, glabrous, midnerve and lateral nerves usually plainly visible, margin entire, apex obtuse to acuminate; flowers borne singly or in 2's or 3's at the nodes, on pedicels 1–2 cm. long; calyx cup-shaped, glabrous, about 2.5 mm. long, usually 5-lobed, the lobes about half as long as the tube; corolla lavender, rotate-campanulate, tube 3–7 mm. long, 1 mm. or less in diameter at top of ovary, about 3 mm. in diameter at summit, glabrous without, lobes (4) 5, oval, scarcely as long as the tube, sometimes only ⅓ as long, margins not ciliate; stamens about as long as the corolla, but apparently much exserted, due to the spreading of the lobes, filaments subequal, adnate to middle of corolla-tube, glabrous at point of adnation, but corolla-tube and filaments bearing tufts of hairs just above this region, anthers 1 mm. or less long; style equalling or exceeding the stamens; berry ovoid, fleshy, about 1 cm. long and ½–⅔ as thick, salmon-red, 10–20-seeded.

Distribution: a commonly cultivated plant throughout most of the United States, West Indies, and parts of Mexico; frequently well established as an escape from cultivation.

Representative material:

Canada: Port Mouton, Queens Co., Nova Scotia, Aug. 18, 1920, *Bissell & Graves 22404* (G, NY, PA).

United States of America: roadside, s. of Grace Point, Block Island, Rhode Island, Sept. 15, 1913, *Fernald, Long & Torrey 10346* (G, PA); grassy roadside, Cayuga Heights, Ithaca, New York, Sept. 18, 1914, *Wiegand 3108* (NY); College Point, New Jersey, Sept. 1879, *Schrenk* (US); Mt. Crawford, Rockingham Co., Pennsylvania, Aug. 7, 1893, *Heller & Halbach 1171* (C, F, NY, PA, US); Ellicott City, Maryland, Sept. 1816, *Arsène 1388* (US); Georgetown, District of Columbia, July 29, 1893, *Boettcher 267* (C, F, G, MBG, S); Sanford, Florida, Aug. 1922, *Rapp* (NY); Bowling Green, Kentucky, Aug. 1899, *S. F. Price* (MBG); Hubbardston, Michigan, coll. of 1876, *C. F. Wheeler* (P); roadside hedge, Stark Co., Illinois, Aug. 4, 1907, *Chase 1534* (US); Ames, Iowa, Aug. 26, 1896, *Pammell & Combes 203* (F, G, MBG, NY, US); Bear Creek bottoms, Hannibal, Missouri, Sept. 3, 1913, *Davis 1336* (MBG); near Page, Leflore Co., Oklahoma, Sept. 27, 1914, *Blakley 3415* (MBG); Lake Charles, Louisiana, Sept. 1906, *Cocks 3213* (G); vicinity of Santa Fe, New Mexico, Oct. 3, 1913, *Rose & Fitch 17688* (NY, US); Great Falls, Montana, coll. of 1889, *F. W. Anderson* (F); Murray, Salt Lake Co., Utah, Sept. 21, 1916, *W. W. Jones 231* (G); Elko, Nevada, Aug. 11, 1918, *Abrams 7249* (S); about old cellar on Court St., Salem, Oregon, July 30, 1923, *J. C. Nelson 4903* (PA); Beckwith, Sierra Co., California, July, 1903, *Hall & Babcock 4462* (C).

Bermuda: garden, Mangrove Park, Aug. 1913, *Brown & Britton 1729* (NY, PA).

There are several horticultural varieties of this species, a good treatment of which may be found in Bailey's Cyclopedia of Horticulture.

2. L. Morongii Britton, Ann. N. Y. Acad. Sci. **7**: 180. 1892.
Pl. 14, figs. 1–3.

L. Morongii Brit. var. *typicum* Hassler, Fed. Rep. Spec. Nov. **15**: 241. 1918.

A sparingly branched, spreading, spiny, glabrate shrub or small tree 1–4 m. tall; branches stout, densely leafy and floriferous, with few to many very stout spines 10–15 mm. long, tan to dark gray; leaves borne in fascicles of 1–5, blades usually ovate, sometimes very broadly so, 3–6 cm. long, 1.5–4 cm. broad, veins plainly visible beneath, apex acute to obtuse, margins undulate, entire or minutely crenulate, base tapering to a petiole 5–15 mm. long; flowers borne in glomerules of 5–20 at the nodes, frequently densely aggregated on short lateral or terminal branchlets, nodes with dense gray tomentum, pedicels 1–3 mm. long; calyx campanulate, 1.5–2.5 mm. long, ⅔ as broad, glabrate, except for small tuft of hairs on the tips of the four broadly triangular lobes, these half as long as the tube, or less; corolla infundibuliform, whitish, tube 3–4 mm. long, 2–2.5 mm. wide at summit, about 1 mm. wide at base, glabrous exteriorly, lobes 4, ovate, ½–⅔ as long as tube, spreading, their margins ciliate; stamens about equal to corolla-lobes, hence slightly exserted, filaments adnate to slightly more than 1 mm. from base of corolla-tube, densely hairy for nearly 2 mm. from point of adnation, adjacent corolla-tube also hairy above and below base of filaments, anthers 1 mm. or less long; style usually slightly exceeding stamens; berry globose, 2.5–3.5 mm. in diameter, several-seeded.

Type: Asuncion, central Paraguay, 1888–90, *Morong 161* (NY).

Distribution: central Paraguay westward to the Territory of Chaco, Argentina.

Material seen:

Paraguay: L'Assomption, May 20, 1884, *Balansa 4096* (D); near Concepcion, Aug. 1901–02, *Hassler 7201* (D, KEW, V); Conception de Paraguay, Nov. 1892, *Kuntze* (NY); northern Paraguay, Nov. 1892, *Kuntze* (NY); Asuncion, central Paraguay, coll. of 1888–90, *Morong 161* (G, MBG, NY type, PA, US).

Argentina: Terr. de Los Misiones, Posadas, Apr. 9, 1930, *Rodriguez 166* (MBG); Territorio del Chaco, *Jörgensen 2208* (G, MBG).

The writer has not seen either of the two plants cited by Hassler, Fed. Rep. Spec. Nov. **15**: 241. 1918, under his *L. Morongii* var. *indutum* (*Hassler 2669*, *7201*) which was characterized as follows: "Rami sparse, folia supra et subtus, petioli dense pilis simplicibus

viscidulis, induti, pulvinuli albicanti-tomentosuli." Therefore, it is considered wisest to treat these plants as a valid variety until there is opportunity to study some material which may be considered as authentic.

2a. L. Morongii Brit. forma **parvifolium** C. L. Hitchcock, f. nov.[40]

Leaves rhombic-ovate, 1–2 cm. long, 0.8–1.2 cm. broad, thicker than those of the species.

Type: "El Charco," Prov. Santiago del Estero, Argentina, Feb. 15, 1930, alt. 300 m., *Venturi 10105* (MBG); Tucuman, Dec. 19, 1913, *Rodriguez 1192* (MBG).

The pubescence and the characters of the corolla are as in the species, but the leaves are much smaller and more leathery in texture.

3. L. cuneatum U. Dammer in Engl. Bot. Jahrb. **37**: 169. 1905. Pl. 14, figs. 17–19.

L. pruinosum var. *puberulum* Griseb. Abhandl. König. Ges. Wiss. Gött. (Symb. Fl. Arg.) **24**: 245. 1879.

L. colorans U. Dammer, Meded. Rijks Herb. Leid. 29: 22. 1916.

A densely pubescent, well-armed shrub 2–3 m. tall; branches spreading, armed with slender, needle-like spines 5–12 mm. long, young branches densely lanate with branched hairs, tardily glabrate and tan in age; leaves borne singly or in 2's, blades broadly ovate or nearly rotund to oblong or obovate, 1–3 cm. long, 0.8–2.4 cm. broad, floccose with much-branched hairs, young leaves cinereous, apex rounded or obtuse, less commonly acute, margins entire, sometimes undulate, rounded to cuneate at base; petioles 0.3–2 cm. long, densely lanate; flowers borne in glomerules of 5–15 at the nodes, nearly sessile, pedicels 1–2 mm. long; calyx 1.5–2 mm. long, about as broad, sparingly pubescent, irregularly 4- or 5-lobed, frequently 2-lipped, the lobes ⅓–½ as long as the tube, their margins rather conspicuously short lanate-ciliate with simple and branched hairs; corolla infundibuliform, tubular por-

[40] **L. Morongii** Brit. forma **parvifolium** C. L. Hitchcock, f. nov.; foliis rhombo-ovatis, 1–2 cm. longis, 0.8–1.2 cm. latis. "El Charco," Prov. Santiago del Estero, Argentina, Feb. 15, 1930, alt. 300 m., *Venturi 10105* (Missouri Botanical Garden Herbarium, no. 986382, TYPE).

tion about 4 mm. long, 3 mm. in diameter at summit, 1.25–1.75 mm. in diameter above ovary and at base, glabrous without, lobes 4 or 5, oblong-oval, 1.5–2 mm. long, spreading or revolute; stamens 4 or 5, exserted 1–2 mm. from corolla-tube, filaments subequal, adnate to about 1.5 mm. above base of corolla-tube, densely lanate the first 2–2.5 mm. of their length, adjacent corolla-tube also conspicuously pubescent above and below point of filament adnation, anthers 1.25 mm. long, thecae attached to connective near their middle; style equal to or slightly longer than stamens; berry several-seeded, disc evident.

Type: Caiza, Gran Chaco, Bolivia, in campo aprico, March 20, 1902, *Fries 1430* (ST).

Distribution: apparently known only from the region of Gran Chaco.

Material seen:

Bolivia: Caiza, in campo aprico, March 20, 1902, *Fries 1430* (ST type); im Kamp des linken Pilcomayo-Ufers, Dec. 14, 1910, *Herzog 1097* (ST type *L. colorans*, D, V); photograph of type collection at Berlin (G).

Argentina: Oran, Urundel, Prov. Salta, Dec. 1, 1913, *Rodriguez 1145* (MBG); Pasaje del Rio Juramento, Prov. Salta, Feb. 21, 1873, *Lorentz & Hieronymus 363* (NY, US); Salta, Oran, Rio Piedras, Nov. 5, 1911, *Rodriguez 176* (MBG); Salta, Nov. 1877, *Lorentz & Grisebach* (KEW); Quebrada de San Lorenzo, Prov. Salta, Oct. 23, 1925, *Schreiter 94* (MBG); Jujuy, coll. of 1913, *Schuel 28 & 124* (V).

Lycium cuneatum resembles *L. Morongii* very closely in habit and flower characters, the differences being that *L. cuneatum* has dense pubescence, broadly ovate leaves, and apparently a shorter calyx and somewhat broader corolla. *Lycium colorans* cannot be given any nomenclatural recognition, as the pubescence and flower characters are identical with *L. cuneatum;* in fact the only difference in the two plants is that *L. colorans* is slightly more cinereous and the leaves are more nearly rotund.

4. **L. Martii** Sendtner in Mart. Fl. Bras. **10**: 154. 1846; Dunal in DC. Prodr. **13**[1]: 512. 1852. Pl. 14, figs. 4–6.

L. Martii α normale Terrac. Malpighia **4**: 534. 1891.

A sparingly branched, armed, sparsely pubescent shrub 2–3 m. tall; branches slender, very leafy, armed with few sharp spines 6–10 mm. long, reddish-brown, densely hirtellous and grayish on young parts, glabrate with age; leaves borne singly or in 2's or 3's, blades ovate, elliptic, or obovate, 3–5 cm. long, 1–2.5 cm. broad, thin, sparsely pubescent with simple or branched hairs on veins, apex acute to obtuse, margins entire, base cuneate-attenuate to a petiole 8–15 mm. long, the petioles more densely pubescent; flowers borne in glomerules of 2–7 on pedicels about 3 mm. long; calyx campanulate, 1.5–2 mm. long, slightly broader, tube glabrous, irregularly 4–8-lobed, the lobes very short, with sparsely ciliate margins; corolla infundibuliform, tubular portion 4–4.5 mm. long, about 3.5 mm. in diameter at apex, 2 mm. in diameter at base, glabrous exteriorly, lobes 5, spreading or deflexed, oblong-ovate, about 2 mm. long, their margins ciliate; stamens 5, about equal to corolla-lobes, exserted from tube about 2 mm., filaments adnate to about 1 mm. or less from base of corolla, densely lanate for the first 3 mm. of their length, adjacent corolla-tube also pubescent, anthers 1 mm. long; berry ovoid, about 4 mm. long, 6–10-seeded.

Type: on the San Francisco River near Joazeiro, Prov. Bahia, Brazil, May, 1818, *Martius 2287* (probably at Munich).[41]

Distribution: northeastern Brazil, from the Province of Cearà to the Province of Bahia.

Material seen:

BRAZIL: Caminho Limoeiro, Prov. Cearà, Apr. 14, 1910, *Löfgren 749* (ST); Vargem, Prov. Cearà, Apr. 12, 1910, *Löfgren 523* (ST); Arneiroz, Prov. Cearà, Apr. 8, 1910, *Löfgren 487* (ST).

The above description was drawn from material labelled "L. Martii" by R. E. Fries. These plants fit Sendtner's description perfectly, and they are almost certainly his species. As here described, *L. Martii* is very similar to *L. Morongii;* the five-lobed corolla of the former is probably not constant, and the same opinion may be hazarded for the four-lobed condition in *L.*

[41] Since the above statement was written, a photograph of the type specimen of *Lycium Martii* Sendt., namely, *Martius no. 2287*, in the Herbarium of the Botanical Museum at Munich, was received through the kindness of Dr. Karl Suessenguth. The photograph, now deposited in the Missouri Botanical Garden Herbarium, verifies in all details the writer's interpretation of this species.

Morongii. Aside from this character, it appears that the corolla of Sendtner's species is broader and less constricted above the ovary, and that the filaments are inserted lower on the corolla-tube than in Britton's species. However, the writer feels that it is altogether probable that *L. Morongii* and possibly *L. cuneatum* will be found to be conspecific with *L. Martii* when there is enough material available that one may obtain a clear idea of the range of variation within the species. Until such time it is considered best to treat them as three very closely related species.

5. **L. glomeratum** Sendtner in Mart. Fl. Bras. **10**: 154. 1846; Dunal in DC. Prodr. **13**[1]: 512. 1852; Miers, Ann. & Mag. Nat. Hist. II, **14**: 139. 1854, and Ill. S. Amer. Pl. **2**: 115, *pl. 68F.* 1857. Pl. 14, figs. 7–9.

L. glomeratum var. *obovatum* Miers, Ann. & Mag. Nat. Hist. II, **14**: 139. 1854, and Ill. S. Amer. Pl. **2**: 115. 1857.

L. Martii β glomeratum Terrac. Malpighia **4**: 534. 1891.

L. Martii β glomeratum var. *obovatum* (Miers) Terrac. *l. c.*

A very leafy, glabrous shrub or small tree, usually unarmed, but spines sometimes present in leaf-fascicles; branches long, apparently spreading, slender but not flexuous, tan to reddish; leaves 1–5 at the nodes, obovate to lance-ovate or ovate, 2–8 cm. long, 1–3 cm. broad, rounded to acute at apex, rounded to cuneate at base, with petiole 3–10 mm. long, glabrous, or less commonly, minutely and sparsely pubescent, margins entire, midnerve and lateral nerves evident; flowers borne in small glomerules of 5–20 at the nodes, pedicels 2–5 mm. long; calyx campanulate, 2–2.5 mm. long, about as wide, irregularly 3–6-lobed, the lobes triangular, ½ as long to equal to tube, their margins sparsely ciliate to minutely lanate-ciliate; corolla infundibuliform, tubular portion 4.5–5.5 mm. long, much narrowed for nearly ½ its length, then greatly expanded, about 1 mm. in diameter at base, slightly less above ovary, 2.5 mm. at summit, sparsely to densely pubescent externally for ⅓ its length; lobes (4?) 5, ovate, 2–2.5 mm. long, spreading, their margins ciliate, stamens about equal to corolla-lobes, thus usually exserted, filaments subequal, adnate to 1–1.5 mm. from base of corolla-tube, densely pilose from base to top of corolla-tube, adjacent corolla-tube also pubescent, but less

densely so, anthers about 1 mm. long; style equalling or slightly exceeding the stamens; berry ovoid, 3–5 mm. in diameter, 30–50-seeded.

Type: in Prov. Alagoas, Brazil, April, 1839, *Gardner 1370* (probably at Munich).

Distribution: from eastern coast of Brazil to Bolivia and western Argentina, along the rivers of the interior.

Material seen:

Brazil: without locality, *Burchell 8967* (KEW); Ilha de San Pedro, near mouth of San Francisco R., Prov. Alagoas, coll. of 1838 *Gardner*, TYPE collection *L. glomeratum* var. *obovatum* (KEW); Prov. Alagoas, Apr. 1839, *Gardner 1370*, TYPE collection (D, KEW, NY, US, V).

Bolivia: Gran Chaco, Tatarenda, in margine silva, loco aprico, Oct. 17, 1902, *Fries 1385* (ST).

Paraguay: Berges du Rio-Paraguay à l'Assomption, Apr. 18, 1842, *Balansa 2082* (KEW, ST).

Uruguay: Montevideo, May, 1867, *Gibert 6411* (KEW).

Argentina: Terr. de Misiones, Santa Ana, Feb. 10, 1913, *Rodriguez 762* (MBG); Salado, Puente Mihura, June, 1930, *Jurado* (MBG); Reconquista, March 24, 1904, *Venturi 203* (MBG); Ciudad Corrientes, Oct. 10, 1922, *Escuela Centenario 77* (MBG).

Due to the extreme variation in leaf shape in this species it does not seem wise to recognize Miers' variety *obovatum*, as the leaves on that plant vary from obovate to elliptic and oblong-ovate.

6. L. cestroides Schlecht. Linnaea **7**: 70. 1832; Mart. Fl. Bras. **10**: 155. 1846; Hieron. Bol. Acad. Cienc. Cord. **2**: 41, *pl. 2, figs. 12–13.* 1876; Griseb. Abhandl. König. Ges. Wiss. Gött. **19**: 217. 1874 (Pl. Lorent. 169. 1874), and **24**: 245. 1879; Miers, Ann. & Mag. Nat. Hist. II, **14**: 134. 1854, and Ill. S. Amer. Pl. **2**: 110, *pl. 67F.* 1857. Pl. 16, figs. 13–15.

Acnistus cestroides Miers, Hook. Lond. Jour. Bot. **4**: 343. 1845, and Ill. S. Amer. Pl. **1**: 23. 1850; Dunal in DC. Prodr. **13**^{1}: 500. 1852.

L. cestroides α normale Terrac. Malpighia **4**: 534. 1891.

A shrub or small tree 1–5 m. tall; branches slender and somewhat flexuous, unarmed or with few spines toward ends, greenish-yellow, covered with dense soft pubescence when young, tardily glabrate with age; leaves sometimes borne singly on young branches, more commonly in fascicles of 2–6, the inner ones much reduced, blades ovate to ovate-lanceolate, less commonly nearly elliptic, 1.5–7 cm. long, 0.5–3.5 cm. broad, acute to acuminate, rounded or tapering gradually to a distinct petiole 3–12 mm. long, densely pubescent when young, glabrate in age, pubescence persistent on petioles; flowers borne singly or in fascicles of 2–6 at the nodes or on short lateral branchlets 1–6 cm. long, these usually with internodes very much shortened, the flowers thus often densely aggregated; pedicels 2–9 mm. long, densely puberulent; calyx tubular-campanulate, 3–5 mm. long, 2–3 mm. in diameter, 5-lobed, these triangular-acuminate, 1–2 mm. long, sparsely puberulent, margins densely white-lanate-ciliate; corolla blue to dark purple, 14–20 mm. long, including the lobes, 2–3 mm. in diameter at summit, 1.5 mm. at base, glabrous without, lobes 5, ovate, spreading, 1.5–2 mm. long, their margins densely white-lanate-ciliate; stamens 5, adnate to about middle of corolla-tube or slightly below, filaments unequal, 2 about equalling corolla-tube, 1 only half as long, other 2 intermediate in length, pilose at base for about 1 mm., corolla-tube somewhat hairy above adnate portion of filaments, anthers 1–1.5 mm. long; style slightly longer or shorter than the shortest stamens; berry globose or ovoid, 5–7 mm. long, 3–5 mm. in diameter when ripe, with 10–20 seeds.

Type: "In Brasilia meridionalis prope San Jose, Uruguay," *Sellow* (probably at Berlin).

Distribution: central Argentina, from Buenos Aires north to Bolivia and east to Uruguay.

Material seen:

Brazil: without locality, *Sellow* (KEW, ST, V), probably type collection and therefore from Uruguay.

Uruguay: San Jose de Uruguay, Brasil, *Sellow* (G, photograph of type at Berlin); Atahualpa, Dept. Montevideo, Rep.-Oriental del Uruguay, Nov. 1925, alt. 30–40 m., *Herter 279* (C, D, F, G, MBG, NY, ST); Montevideo, June, 1867, *Gibert 18* (KEW);

vicinity of the city of Montevideo, June 22–23, 1882, *Ball* (G, NY); Miguelete, Montevideo, May, 1927, *Herter 279a* (US).

Bolivia: Tarija, locis apricis, Jan. 16, 1902, *Fries 1032* (ST).

Argentina: Arroyo del Medio, loco aprico in margine silva, Prov. Jujuy, June 29, 1901, *Fries 351* (ST); Prov. Jujuy, coll. of 1913, *Schuel 72* (V); Alesnancia, Prov. Salta, Dept. Guachipas, Nov. 4, 1929, *Venturi 9816* (MBG, ST); Agua Caliente, Prov. Salta, Dept. Candelaria, Oct. 30, 1927, *Venturi 5431* (F); Capia, Prov. Tucuman, Dec. 23, 1911, *Rodriguez 217* (MBG); circa Sta. Ana, Prov. Tucuman, Nov. 1902, *Baer 73* (D); Prov. Tucuman, Oct. 12, 1923, alt. 750 m., *Venturi 2549* (G, US); Villa Lujan, Prov. Tucuman, Dec. 1918, *Venturi 24* (MBG); Tucuman, Nov. 1892, *Kuntze* (NY, US), *Tweedie* (V); in rocky places, Andalgala, Prov. Catamarca, Oct. 10, 1916, alt. 1070 m., *Jörgensen 11511* (ST); Andalgala, Prov. Catamarca, Sept. 9, 1915, *Jörgensen 970* (C, G, MBG, US); Balcogna, Prov. Catamarca, Dept. Alta, Jan. 14, 1928, alt. 1250 m., *Venturi 7136* (F); Santiago del Estero (probably), coll. in 1836, *J. Tweedie* (KEW); "El Charco," Santiago del Estero, Feb. 13, 1930, alt. 300 m., *Venturi 10115* (MBG, ST); Prov. Cordoba, Jan. 25, *Lossen 81* (F, G, MBG); Cordoba, Dec. 1891, *Kuntze* (NY); Cordoba, pr. urbem, Oct. 26, 1877, *Hieronymus* (F); Cordoba, Oct. 6, 1877, *Hieronymus* (US); Cordoba, pr. urbem, Oct. 9, 1877, *Hieronymus* (F); Estancia Germanica prope Cordoba, June–Dec. 1874, *Lorentz 32* (D, V); Prov. Cordoba, Rio Seballos, Dec. 8, 1876, *Hieronymus* (F, US); Sierra Chica de Cordoba, Rio Seballos, Dec. 8, 1876, *Hieronymus 593* (D); Cordoba, March 3, 1880, *Galander* (NY); cerca Las Rosas, Prov. Cordoba, June 13, 1898, *Stuckert 4936* (D); Casa Bamba, Sierra de Cordoba, Nov. 1899, *Stuckert 7905* (D); La Plata, Prov. Buenos Aires, *Parodi 8702* (G); parks, gardens, and environs of city of Buenos Aires, June, 1913, *Curran 103* (US); Rivadavia, *Molfino* (MBG).

Superficially, this species resembles *Cestrum* more than it does *Lycium*, but it has a well-coiled embryo, and must be placed in this genus. Because of the fact that the nodes are so closely approximated in some instances that the flowers appear to be borne in glomerules, Miers placed the species in the genus *Acnistus*, but later realized his mistake.

Hieronymus, Bol. Acad. Cienc. Cord. **2**: 43, *pl. 2, figs. 1–8.* 1876, described what he considered to be a hybrid between *L. cestroides* and *L. argentinum* (*ciliatum*) from "Chacra Germania de la Merced," near Cordoba, Argentina. Material labelled *L. arg.* × *cestroides* in his handwriting, taken from that locality in 1871 and in 1876, answers his description and plate well, and it is safe to assume that it is part of the material with which he worked. An examination of the pollen shows that about 40 per cent of it is abortive. Aside from this evidence, the plants combine characters of the two species, as shown by plate 19, figs. 10–12. A summary of the evidence will show why the author considers that Hieronymus was correct in his deductions.

Leaves—much like those of *L. cestroides.*

Pubescence—much like that of *L. cestroides.*

Flowers—borne singly or in 2's as in *L. ciliatum.*

Calyx—tube like that of *L. cestroides,* lobes between those of the two species, not lanate-margined, but like those of *L. ciliatum.*

Corolla—tube between the two, much longer than in *L. ciliatum,* much more expanded than in *L. cestroides;* lobes intermediate in size; margins as in *L. ciliatum,* base of tube pubescent as in *L. ciliatum,* but not nearly so much so; filaments like those of *L. cestroides* (not glandular fringed), but slightly more pilose and less adnate to the corolla-tube, about the same degree of adnation, proportionately, as in *L. ciliatum,* more nearly equal than in *L. cestroides;* stigma about same length, proportionally, as in *L. ciliatum* (much longer than in *L. cestroides*).

Those collections which are considered to be of such a hybrid nature are:

ARGENTINA: Chacra de la Merced bei Cordoba, Oct. 17, 1875, *Hieronymus 493* (F, NY, US), and Oct. 11, 1881 (D); Cordoba, Nov. 1875, *Hieronymus* (C, F, G, NY, US, V); Provincia de Cordoba, Chacra de la Merced, Oct. 1871, *Hieronymus* (NY); Cordoba, coll. of 1873, *Lorentz & Hieronymus* (NY); Chacra de la Merced, near the city of Cordoba, coll. of 1876–77, *Hieronymus* (D, F, KEW, US); Cordoba, Sept. 1876, *Hieronymus* (V).

7. L. cyathiformum C. L. Hitchcock, sp. nov.[42]

Pl. 14, figs. 32–34; pl. 20.

A spreading, pubescent, sparingly armed shrub 2–3 m. tall; branches slender, very leafy, spines few, 5–10 mm. long, densely pubescent with branched hairs, tardily glabrous, tan or grayish; leaves ovate to ovate-lanceolate, oblong, or rounded, 3–5 in a fascicle, blades 1.5–5 cm. long, 1–3 cm. broad, sparsely pubescent with branched hairs, the veins and margins more densely pubescent, apex acuminate to rounded, entire, base rounded to a 5–12 mm. long, very densely dichotomously branched-pubescent petiole; flowers borne singly or in groups of 2–5 at the nodes, pedicels 3–7 mm. long, densely pubescent; calyx cup-shaped, pubescent with branched hairs, 3–4 mm. long, 2–2.5 mm. wide, irregularly 4–5-lobed, sometimes cleft to middle on one side, the lobes acute, 1–1.5 mm. long, their margins lanate-ciliate; corolla infundibuliform-cyathiform, tubular portion 7–10 mm. long, 2.5–3.5 mm. in diameter at the top, 1.5 mm. in diameter at the base, contracted slightly above ovary, glabrous without, lobes 5, oblong-rounded, 1.5 mm. long, spreading, their margins densely tawny-lanate-ciliate; stamens partially exserted, filaments subequal, about equalling corolla-tube, adnate to about ⅓ the length of the corolla-tube, densely hairy for first 2 mm. of their length, adjacent corolla-tube also pubescent above and below region of adnation of filaments, anthers 1.25 mm. long; style slightly longer than stamens, about equal to corolla-lobes; berry ovoid, 6–8 mm. long, several-seeded.

Type: Gran Chaco, Bolivia, "Tatarenda in loco aprico in dumetis, March 26, 1902," *Fries 1473* (ST).

Distribution: region of Gran Chaco.

[42] **L. cyathiformum** C. L. Hitchcock, sp. nov., fruticosum, pubescentissimum glandulosumque, spinosum, 2–3 m. altum; ramis gracilibus, foliosissimis; foliis ovatis, ovato-lanceolatis vel oblongis, 3–5-fasciculatis, laminis 1.5–5 cm. longis, 1–3 cm. latis, semi-stellato-pubescentibus; floribus solitariis vel 2–5-fasciculatis, pedicellis, 3–7 mm. longis; calyce campanulato, 3–4 mm. longo, 2–2.5 mm. lato, 4–5-fido, lobis 1–1.5 mm. longis; corolla infundibuliformi-cyathiforma, tubo 7–10 mm. longo, ad verticem 2.5–3.5 mm. in diametro, ad basem 1.5 mm. in diametro, externo glabro, 5-fido, lobis oblongo-rotundis, 1.5 mm. longis, marginibus lanato-ciliatis; staminibus corollae tubi partem mediam adhaerentibus, basi corollae intraque villosis; stylo corollae lobis subaequale; bacca 6–8 mm. longa, plurisperma. Collected at Gran Chaco, Bolivia, "Tatarenda in loco aprico in dumetis, March 26, 1902," *Fries 1473* (Stockholm Botanical Museum, TYPE).

Material seen: TYPE collection, and one specimen labelled "Sandy places, Pampas," June 1864, *Pearce* (KEW), either from northern Argentina or from Peru.

8. **L. vimineum** Miers, Ann. & Mag. Nat. Hist. II, **14**: 140. 1854, and Ill. S. Amer. Pl. **2**: 116, *pl. 69B*. 1857.

Pl. 14, figs. 10–12.

L. chilense γ *implexum* var. *vimineum* (Miers) Terrac. Malpighia **4**: 530. 1891.

A partially scandent, glabrate shrub 3–7 m. tall; branches very slender, flexuous and apparently recurved or drooping, armed with few very sharp spines about 5 mm. long, tan; leaves linear-lanceolate to narrowly oblong-oblanceolate, 15–30 mm. long, 2–5 mm. broad (probably larger on old branches), acute, glabrous, 1–3 in a fascicle; flowers 1–3 in a fascicle, pedicels about 4 mm. long; calyx cup-shaped, 2.5–3 mm. long, 2–3 mm. in diameter, glabrous except for the ciliate margins of the 4 triangular lobes 1 mm. long; corolla broadly tubular-obconic, constricted somewhat above ovary, tubular portion 4–5 mm. long, 3 mm. in diameter at summit, glabrous exteriorly, lobes 4 (5?), ovate-cuneate, 2–2.5 mm. long, spreading, their margins conspicuously ciliate; stamens 4, equal to corolla-lobes, thus exserted 2–3 mm. when lobes spread, filaments adnate to a little below the middle of the corolla-tube, subequal, densely woolly-pilose for about 1 mm. just above the glabrous base, adjacent corolla-tube also densely pubescent, anthers 1.5 mm. long; style "equal to stamens," or exceeding them 1–2 mm.; berry unknown.

Type: near the town of Santa Fe, Province of Santa Fe, Argentina, *Tweedie* (British Museum).

Distribution: known only from the type locality.

Material seen: near town of Santa Fe, Prov. Santa Fe, *J. Tweedie* (KEW TYPE collection); Santa Fe, Rio Parana, March, 1923, *Hauman* (MBG); Santa Fe, desembocadura del Salado, Apr. 1920, *Molfino* (MBG).

This species suggests *L. chilense* at first glance, but is quite distinct from that species; the filaments are not glandular at the base, and the corolla is glabrous exteriorly. Tweedie's label reads "This is a shrub 12 to 20 feet high, very plentiful near the town of Sta.

Fea," but since the material obtained by him consisted of snips from the ends of the branches, the foregoing description was of necessity drawn up by inference as far as the habit of the plant is concerned.

9. **L. nodosum** Miers, Ann. & Mag. Nat. Hist. II, **14**: 139. 1854, and Ill. S. Amer. Pl. **2**: 115, *pl. 69A*. 1857. Pl. 15, figs. 16–18.

L. chilense Miers ex Bert. var. *heterophyllum* Hassler, Fed. Rep. Spec. Nov. **15**: 240. 1918, as to specimen cited.

L. chilense γ *implexum* var. *nodosum* (Miers) Terrac. Malpighia **4**: 530. 1891.

An open, somewhat scandent, glabrate shrub, unarmed, or with few spines, 1–3 m. tall; branches long, slender, flexuous, silvery-gray; leaves 1–3 in a fascicle, blades spatulate to oblong-elliptic or broadly ovate, 5–10 (25) mm. long, 3–5 (10) mm. broad, very thin in texture, rounded or obtuse, tapering to a petiole 2–5 mm. long, nodes usually rather close together; flowers borne singly, pedicels 3–5 mm. long, glabrous; calyx 1–1.5 (2) mm. long, 4 (5)-lobed, the lobes about ⅓ length of tube, acute, their margins sparsely ciliate, rest of calyx glabrous; corolla tubular-campanulate, the tube 4–5 mm. long, 2.5 mm. in diameter at summit, 1 mm. or slightly more at base, glabrous without, lobes 4 (5), oblong-ovate, 1.5–2 mm. long, minutely ciliate, spreading, or, more commonly, reflexed with tips revolute; stamens usually exserted 2.5–3.5 mm. due to spreading of corolla-lobes, filaments somewhat subequal, one usually a little shorter than others, adnate to approximately ⅓ way from base of corolla-tube, glabrous for ½ mm. from base, densely clothed with branched hairs for about 1 mm. above this point, adjacent corolla-tube also pubescent; style equal to or as much as 1 mm. longer than stamens; berry ovoid, 5–6 mm. long, red, many-seeded.

Type: Tucuman, Argentina, *Tweedie* (British Museum).

Distribution: northern Argentina, from the Province of Tucuman northward and eastward to the region of the Gran Chaco in Bolivia and Paraguay.

Material seen:

Bolivia: in regione cursus inferioris fluminis Pilcomayo, Aug. 1906, *Rojas 504* (KEW, V); Gran Chaco, Colonia Crevaux (Rio

Pilcomayo), in campo uliginoso, Apr. 18, 1902, *Fries 1652* (ST).

PARAGUAY: Puerto, Gran Chaco in silvis, May 14, 1895, *Anisits 2186* (ST).

ARGENTINA: La Fidelidad, Terr. Chaco, Apr. 1898, *Jörgensen 2825* (G, MBG, US); Prov. Tucuman, *J. Tweedie* (KEW, TYPE collection); Chañar Pozo, Tucuman, Dec. 1919, *Venturi 708* (MBG); Formosa, La Fidelidad, Apr. 1918, *Jörgensen 2825* (MBG).

L. nodosum is most closely related to *L. Tweedianum*, from which it differs in habit, in having more slender branches with fewer spines, and in having a calyx only half as large; moreover, the corolla is shorter and the stamens are more exserted in proportion to the corolla length. Where the two species overlap in the region of the Gran Chaco, it is difficult to distinguish them, as they appear to intergrade; however, the two species are so strikingly different in general aspect and corolla character that it seems certain they are distinct. *L. nodosum* differs from *L. vimineum* in that its calyx is much smaller, and the corolla-tube is only half as broad.

10. L. Tweedianum Griseb. Abhandl. König. Ges. Wiss. Gött. **19**: 216. 1874 (Pl. Lorent. 168. 1874), and **24**: 245. 1879.
Pl. 15, figs. 1–3.

L. Tweedianum Griseb. var. *pruinosum* (Griseb. ?) Hassler, Ann. Cons. et Jard. Bot. Genève **20**: 188. 1917.

L. paucifolium Rusby, Mem. Torr. Bot. Club **6**: 91. 1896.

L. confusum U. Dammer, Arkiv f. Bot. **1**: 404. 1903.

L. subtridentatum U. Dammer, Meded. Rijks Herb. Leid. 29: 25. 1916.

Grabowskia Schlechtendalii as treated by Chodat, Bull. Soc. Bot. Genève II, **8**: 150. 1916, as to citation of specimen.

L. Johnstonii Blake, Contr. Gray Herb. N. S. **53**: 49. 1918.

L. infaustum Miers acc. to Griseb. Abhandl. König. Ges. Wiss. Gött. **19**: 217. 1874 (Pl. Lorent. 169. 1874).

L. salsum Ruiz & Pavon, as treated by Miers, Ann. & Mag. Nat. Hist. II, **14**: 337. 1854, and Ill. S. Amer. Pl. **2**: 131, *pl. 72c.* 1857; Johnston, Proc. Bost. Soc. Nat. Hist. **34**: 243. 1909.

A slender, spiny, somewhat branched, glabrate shrub 1–3 (5) m. tall; branches slender, somewhat flexuous, armed chiefly by

the pungent short branchlets, grayish-tan, somewhat lustrous; leaves glabrous, 1–5 in a fascicle, spatulate to oblong-obovate, 7–25 mm. long, 2–15 mm. broad, apex rounded (acute), base tapering to a short petiole, midnerve evident; flowers few, on very slender pedicels 4–15 mm. long, borne singly at the nodes; calyx cup-shaped, 2.5–4 mm. long, ⅔ as broad, 4 (5)-lobed, the lobes irregular, ⅕–⅓ the length of the tube, sparsely ciliate, otherwise glabrous; corolla narrowly tubular-obconic, constricted above ovary, flared at summit, tube 4.5–6.5 mm. long, about 2.5 mm. in diameter at summit, glabrous, lobes 4 or 5, oblong-ovate, 3–3.5 mm. long, spreading, more or less ciliate; stamens 4 or 5, exserted 3–4 mm. due to spreading of corolla-lobes, filaments subequal or equal, about equalling corolla-lobes, adnate to near the middle of the corolla-tube or slightly above, glabrous at base, but densely pubescent with branched hairs just above the free bases, adjacent corolla-tube also pubescent, anthers 1–1.5 mm. long; style equalling or slightly longer than the stamens; berry red, black with age, ovoid or subglobose, 6 mm. long, 15–25-seeded.

Type: between Rio Saladillo and Santiago del Estero, Argentina, December, 1871, *Lorentz.*

Distribution: from the region of Santiago del Estero, Argentina, along the Pilcomayo River in Bolivia, westward to Peru, and along the coast of Peru, Ecuador, Colombia, and Venezuela.

Material seen:

Argentina: entre al Rio Saladillo y Santiago del Estero, Dec. 1871, *Lorentz* (MBG, photograph of type); Santiago del Estero, Nov. 1877, *Lorentz & Grisebach* (KEW); Quinta, pr. Laguna de la Brea, in solo aprico salso, Prov. Jujuy, June 19, 1901, *Fries 200* (ST type *L. confusum*); Chañar Pozo, Tucuman, Oct. 1919, *Venturi 438* (MBG).

Paraguay: Gran Chaco, Santa Elisa, lat. 23° 10′ S, Dec. 1903, *Rojas 2637* (D, KEW, V type collection *L. Tweedianum* var. *pruinosum*); Gran Chaco, Santa Elisa, lat. 23° 10′ S, Dec. 1903, *Rojas 2707* (D, KEW, V, leaves unusually large, but apparently this species, surely not *L. Martii* as labelled); Pilcomayo R., coll. of 1888–90, *Morong 1006* (G, MBG, NY, PA, US); Gran Chaco, *Pride* (KEW).

Bolivia: im Kamp des linken Pilcomayo-Ufers, Nov. 15, 1910,

Herzog 1095 (ST TYPE *L. subtridentatum*, D, V, photographs of the TYPE collection at Berlin are at MBG and G); Bolivian Plateau, coll. of 1891, *Bang 1098*, TYPE collection of *L. paucifolium* (F, G, MBG, NY TYPE, PA, US, V).

PERU: San Juan, coll. of 1871, *H. Anderson* (KEW); Valley of Lurin and Pachamac, *Mathews 450*, cited by Miers as *L. salsum* (G, KEW); near Lima, coll. of 1862, *Nation* (KEW); Lima, *Wilkes Expl. Exped.* (US); without definite locality, *Pavon*, coll. of 1826 (D).

ECUADOR: Prov. Oro, between Machala and Puerto Bolivar, Aug. 26, 1923, alt. 0–10 m., *Hitchcock 21111* (NY); Chanduy, Prov. Guayas, in litore Maris Pacificis, *Spruce 6505* (D, ST, V); Guayaquil, coll. of 1841, *Hinds* (KEW); Prov. Manabi, lat. ½° S, July 22, 1893, *Eggers 14964* (F, KEW, US).

COLOMBIA: Sevillana, near Cienega, Dept. Magdalena, June 14, 1927, *Salt* (G, US); around Rio Frio, between the Cienega de Santa Marta and foothills, Dept. Magdalena, June 22–30, alt. 0–100 m., *Pittier 1604* (US); near Papare, Santa Marta, Nov. 2, 1898–1901, *H. H. Smith 448* (F, G, MBG, NY, PA, US).

VENEZUELA: between Coro and Alta Gracia, May 1, 1917, *Curran & Haman 750*, TYPE collection *L. Johnstonii* (G TYPE, NY, US); vicinity of Cabo Blanco, D. V., June 8, 1922, *Pittier 10373* (D, US, Venez); Cabo Blanco, June 10, 1917, *Curran & Haman 939* (G, NY, US); Vela de Coro, Apr. 1, 1917, *Curran & Haman 447* (G, US); savannas of Barquisimeto, Lara, Sept. 1923, *Saer 21* (US, Venez); Puerto-Cabello, June 24, 1917, *Curran & Haman 1162* (G, US); among mangroves, Tucacas, July 19, 1923, *Mell* (NY); Cumana, July 3, 1917, *Curran & Haman 1250* (G, NY); Is. of Coche, Aug. 5, 1903, *J. R. Johnston 8* (G); El Valle, Is. of Margarita, Aug. 3, 1903, *J. R. Johnston 61* (C, F, G, NY, P, V).

Grisebach's type has smaller leaves than most of the material included in this species, but it is identical with the other specimens cited in flower characters, whereas *L. confusum* and *L. subtridentatum* are unusual only because of their large leaves. Rusby's species was rightly called *L. paucifolium*, but there is good reason to suppose that the greater part of the leaves on his type have either been shaken off since the plant was collected, or that they

were shed before it was collected. *Lycium Johnstonii* might be considered an average form for this rather protean species. Hassler's variety *pruinosum* is a large-leaved form of the group, but is not at all similar to Grisebach's *L. pruinosum*, the latter a plant which must be referred to *Grabowskia*. Hassler's number 2637 (his variety *pruinosum*) is the one which Chodat erroneously referred to *Grabowskia*.

The writer has not been able to determine the exact identity of *L. salsum* Ruiz & Pavon, Fl. Peruv. **2**: 46, *pl. 183, fig. a.* 1799. It is apparently conspecific with *L. Tweedianum*, but there is also a possibility that it is the same as *L. chilense;* however, the name *salsum* is preoccupied, since Bartram[43] described *L. salsum* from the southeastern United States in 1792. From Miers' plate and his citation, it is clear that the plant which he called *L. salsum* is this species.

Lycium Tweedianum has the most extended range of any of the species of the genus in the Western Hemisphere, remaining remarkably constant in flower characters throughout its range, whereas the leaves, on the other hand, show an unusual amount of variation. One well-marked variety is distinguishable in the West Indian Islands. It is interesting to note that Johnston's plant (number 61) from the Island of Margarita, Venezuela, is the best match for the type of any collection seen.

10a. L. Tweedianum Griseb. var. **chrysocarpum** (Urb. & Ekm.) C. L. Hitchcock, comb. nov. Pl. 15, figs. 4–6.

L. americanum var. *chrysocarpum* Urb. & Ekm. Arkiv f. Bot. **22A**[10]: 49. 1929.

L. spathulifolium Britton, Bull. N. Y. Bot. Gard. **3**: 451. 1905.

Flowers somewhat smaller than in the species, calyx 1–2 mm. long; corolla-tube 4–5 mm. long; leaves 4–10 (20) mm. long, 1–2.5 mm. broad; otherwise as in the species.

Type: edge of mangrove, Juan-Lopez, Peninsula of Barahona, Prov. of Barahona, Santo Domingo, Haiti, July 23, 1926, *Ekman 6729* (ST).

Distribution: West Indian Islands, principally Cuba, Haiti, and the Bahamas.

[43] Bartram, Trav. ed. 2, 57. 1792.

Material seen:

West Indian Islands: Trinidad, British W. Indies, rocky point west end of Monos Island, Apr. 4, 1921, *Britton, Britton & Brown* (NY); rocky plain near settlement, Anagada, *Britton & Fishlock 1033* (NY, US); Republic of Haiti, Feb. 18, 1924, *Ekman H955* (US); low arid wooded coastal region, vicinity of Etroite, Gonave Is., Haiti, March 15–21, 1920, *Leonard 3345* (NY); Haiti, Plaine Cul de Sac, in the arid region at the foot of Marne a'Cabrets, July 18, 1924, *Ekman 955* (ST); Azua, Santo Domingo, March 1913, *Rose, Fitch & Russell 4017* (NY, US); am Yaque Fluss, Prov. Barahona, Santo Domingo, Haiti, Aug. 1910, alt. 50 m., *Fuertes 547* (D, NY, US); Peninsula de Barahona, Prov. de Barahona, Santo Domingo, Haiti, Juan-Lopez, edge of mangroves, Aug. 23, 1926, *Ekman 6728* (ST); vicinity of Port de Paix, Dec. 21–25, 1928, *Leonard & Leonard 11047* (MBG); Peninsula de Barahona, Prov. de Barahona, Santo Domingo, Haiti, Juan-Lopez, edge of mangrove, Aug. 23, 1926, *Ekman 6729* (ST type); Novaliche, Cuba, Nov. 1918, *Hioram 2273* (NY); near mouth of Yojo R., Cajabobo, Cuba, July 17–Aug. 4, 1924, *Leon 12122* (NY); in tidewater-flats, Cannanera, Prov. Oriente, Cuba, Nov. 22, 1922, *Ekman 15741* (ST); Quantanamo in fruticetis ad Glorieta, Prov. Oriente, Cuba, Oct. 22, 1919, *Ekman 10236* (ST); Quantanamo in litor. mar., Prov. Oriente, Cuba, Sept. 25, 1914, *Ekman 2925* (ST); Upper Savannah Inagua, Bahamas, Oct. 26, 1904, *Nash & Taylor 1321*, type collection *L. spathulifolium* (F, NY type); rocky plain, East Caicos, Jacksonville and vicinity, Bahamas, Feb. 26–27, 1911, *Millspaugh & Millspaugh 9084* (F, NY); rocky plain, Ambergris Cay, Caicos Group of Bahamas, March 12, 1911, *Millspaugh & Millspaugh 9292* (F, NY).

11. L. minimum C. L. Hitchcock, sp. nov.[44]

Pl. 14, figs. 23–25; pl. 21.

[44] **L. minimum** C. L. Hitchcock, sp. nov., glabrum, 1–2 m. altum; ramis paucis, gracilibus; foliis filiformibus, 6–12 mm. longis, 0.25–1.25 mm. latis, 2–5-fasciculatis; calyce 2–3 mm. longo, 1.5–2 mm. in diametro, glabro, sed lobis ad vertices pubescentibus, 4–5-fido, prope quamdiu tubo; corollae tubo 3–3.5 mm. longo, ad verticem 2 mm. in diametro ad basem 1 mm. in diametro, extra glabro, 5-fido, lobis 2–2.5 mm. longis; staminibus e corollae tubo 1.5–2 mm. exsertibus, corollae tubi partem mediam adhaerentibus, ad basem pubescentibus; bacca multisperma, sed fructa ignota. Collected on lava beds near the shore, Villamit, Albemarle Island, Galapagos Islands, March 7, 1905–1906, *Stewart 3365* (G type, CA).

A glabrous, almost unarmed shrub about 1–2 m. tall; branches slender, straight, armed with spinose branchlets; leaves filiform, 6–12 mm. long, 0.25–1.25 mm. broad, borne in fascicles of 2–5 from much-enlarged nodes but 1–3 mm. apart; pedicels 3–5 mm. long; calyx 2–3 mm. long, 1.5–2 mm. in diameter, glabrous except for a tuft of hairs at the tips of the lobes, lobes 4 or 5, triangular, nearly as long as the tube; corolla-tube 3–3.5 mm. long, 2 mm. in diameter at apex, somewhat less than 1 mm. in diameter at the base, glabrous without, lobes 5, oval, ⅔ as long as the tube, reflexed, their margins very sparingly ciliate; stamens about equalling corolla-lobes, thus exserted 1.5–2 mm., filaments adnate to point about midway on corolla-tube, densely hairy for 0.5–1 mm. above base of free portion, adjacent corolla-tube glabrous; style exceeding stamens slightly, about 7 mm. long; ovary with well-developed disc, apparently several-ovuled; mature fruit not seen.

Type: on lava beds near the shore, Villamit, Albemarle Island, March 7, 1906, *Stewart 3365* (G).

Distribution: endemic to the Galapagos Islands.

Material seen:

Galapagos Islands: Gardner Island, near Hood Island, Feb. 3, 1905–06, *Stewart 3367* (CA, G); South Seymour Island, May, 1899, *Snodgrass & Heller 584* (G, S); Albemarle Island, March 7, 1905–06, *Stewart 3365* (CA, G type); Turtle Cove, Albemarle Island, near the shore, March 12, 1905–06, *Stewart 3364* (CA); near east end Hood Island, Sept. 25, 1905–06, *Stewart 3368* (CA, G); along shore, Academy Bay, Indefatigable Island, Apr. 4, 1930, *Svenson 34* (B, MBG); Abingdon Island, common bushes forming thickets 2–3 ft. high near the shore, Sept. 21, 1905–06, *Stewart 3363* (CA); Duncan Island, Aug. 15, 1905–06, alt. 300 m., *Stewart 3366* (CA).

In his report on the vegetation of the Galapagos Islands, Dr. Robinson[45] reported this plant for the region, citing a collection by Bauer and the Snodgrass and Heller plant from Seymour Island, but stated that the status of the species could not be ascertained because of the lack of flowers. The type collection is one of the two collections which had either flowers or fruits, and is the only collection which had a perfect flower. Judged from its

[45] Robinson, Amer. Jour. Sci. 14: 199. 1902.

vegetative characters, *L. minimum* resembles *L. californicum* rather closely, but considered from the characters of the flower it is much more similar to *L. Tweedianum*, from which species it seems probable that it had its origin; however, it differs from its relative not only in vegetative characters, but also in the size of the corolla and other flower parts.

12. L. pubescens Miers, Ann. & Mag. Nat. Hist. II, **14:** 339. 1854, and Ill. S. Amer. Pl. **2:** 132, *pl. 72E*. 1857.

Pl. 14, figs. 20–22.

L. patagonicum α normale var. *pubescens* Terrac. Malpighia **4:** 533. 1891.

A much-branched, armed, densely tawny-pubescent shrub; branches densely leafy, tan, covered with dense pubescence, the spines very slender and sharp; leaves linear or linear-spatulate, 3–7 mm. long, 0.5 mm. broad, pubescent with short hairs, somewhat glandular (?), 1–4 in a fascicle, the nodes very close together; flowers borne singly, pedicels 1–2 mm. long; calyx campanulate, tube about 2 mm. long or slightly less, about as wide at top, covered with long multicellular hairs, 0.5 mm. long, lobes 5, lanceolate, acuminate, as long as tube or longer; corolla infundibuliform, tubular portion about 4 mm. long, 2 mm. in diameter at the top, 1 mm. in diameter at the base, glabrous without, lobes 5, oblong-ovate, spreading, nearly 3 mm. long, their margins very minutely and sparingly ciliate; stamens 5, exserted 1–2 mm., filaments unequal, longest ones about 1.5 mm. longer than corolla-tube, adnate below middle of corolla-tube, glabrous at base, but densely pilose about 0.5 mm. above this region, corolla-tube with tuft of hairs between each filament above the point of adnation; style about equalling stamens; berry "1½ lines in diameter."

Type: south of Prov. Buenos Aires, "Patagonia," Argentina, *Tweedie* (British Museum).

Distribution: central and south-central Argentina.

Material seen:

Argentina: south of Prov. Buenos Ayres, *J. Tweedie* (KEW TYPE collection); Cordoba, Sarmiento, Rio V, Jan. 1922, *Serié* (MBG); San Luis, Nogoli, Feb. 9, 1925, *Castellanos* (MBG); San Luis, Alto Pencoso, Nov. 10, 1926, *Castellanos* (MBG);

Santa Cruz, Puerto Madryn, March 30, 1917, *Bonarelli* (MBG).

Lycium pubescens, *L. rachidocladum*, *L. tenuispinosum*, and *L. ovalilobum* are very closely related, and perhaps should be united into two species; but with the limited material at hand they appear distinct enough for specific delimitation. The following chart may help to distinguish them.

ovalilobum	*tenuispinosum*	*rachidocladum*	*pubescens*
	Leaves		
obovate to oblanceolate, 10–30 mm. long, 2–6 mm. broad.	linear-spatulate, 4–10 mm. long, 1–2 mm. broad.	spatulate, 5–10 mm. long, 2–4 mm. broad.	linear, 3–7 mm. long, 0.5 mm. broad.
	Pubescence		
minutely glandular-pubescent.	densely tawny-pubescent.	densely pubescent with glandular or branched hairs.	densely tawny-pubescent, not, or very little, glandular.
	Calyx-lobes		
ovate to lanceolate, 3–5 mm. long.	lanceolate, acute, about 3 mm. long.	linear - lanceolate, 1.5–3 mm. long.	linear, acute, equal to tube or longer.
	Corolla shape and size		
larger than *rachidocladum* or *pubescens* (6 mm.), more slender than *tenuispinosum*.	6 mm. long.	4–6 mm. long.	4 mm. long.
	Proportion of corolla-lobes to tube		
2–5.	1–2, or little more.	2–3.	3–5.
	Pubescence on outside of corolla		
margins of lobes, few on upper portion of corolla.	margins of lobes only, few there.	margins and backs of lobes.	margins of lobes, only.
	Point of adnation of filaments		
about center of corolla-tube.	about center.	above center of corolla-tube.	below center.
	Pubescence at base of filaments		
pilose for 2 mm. above base.	pilose for 1 mm.	pilose at base.	glabrous at base, pilose above.

13. L. rachidocladum Dunal in DC. Prodr. **13**[1]: 519. 1852; Miers, Ann. & Mag. Nat. Hist. II, **14**: 189. 1854, and Ill. S. Amer. Pl. **2**: 125, *pl. 71B*. 1857.

L. chilense subsp. *rachidocladum* (Dunal) Reiche, Anal. Univ. Chil. **123**: 395. 1908, and Fl. Chil. **5**: 315. 1910.

L. chilense β *rachidocladum* (Dunal) Terrac. Malpighia **4**: 529. 1891.

A very spiny, much-branched, spreading shrub; branches stout, sometimes recurved, tan, pubescent when young, spines strong, about 5 mm. long; leaves spatulate, 5–10 mm. long, 2–4 mm. broad, 1–5 in a fascicle, densely pubescent with multicellular (some stellate) hairs, glandular; flowers few, borne singly on pedicels 0.5–2 mm. long; calyx cup-shaped, covered with long, multicellular hairs, tubular portion 1.5–2 mm. long, lobes 4 or 5, linear-lanceolate, 1.5–3 (4) mm. long; corolla infundibuliform, tubular portion 4–6 mm. long, somewhat pubescent on upper portion and on exterior of lobes, lobes 4 or 5, about ⅔ as long as tube, oblong-ovate, spreading or somewhat erect, margins sparsely ciliate; stamens 4 or 5, exserted, filaments subequal, nearly equalling corolla-lobes, adnate to above middle of corolla-tube, pilose at base of free portion, adjacent corolla-tube also hairy, anthers 1–1.5 mm. long; style slightly exceeding the stamens; ovary globose, about 3 mm. in diameter, several-seeded.

Type: "Prope Coquimbo," in Chile, *Gaudichaud 83* (De Candolle Herbarium), according to DC. *l. c.*, but *Gaudichaud 83* in the Delessert Herbarium is from Valparaiso.

Distribution: known only from Coquimbo and Valparaiso.

Material seen:

CHILE: Coquimbo, coll. of 1832, *Colchester* (KEW); Coquimbo, coll. of 1825, *Macrae* (D); Coquimbo, coll. of 1832, *Lindley* (KEW); Coquimbo, Feb. 1888, *Philippi* (KEW, US); Valparaiso, coll. of 1832, *Gaudichaud 83* (D), surely TYPE collection, and possibly the actual type.

Lycium rachidocladum resembles *L. chilense* in flower size, but apparently lacks the external pubescence on the corolla, and appears to be more spiny than the latter species.

14. L. tenuispinosum Miers, Ann. & Mag. Nat. Hist. II, **14**: 190. 1854, and Ill. S. Amer. Pl. **2**: 125, *pl. 71C*. 1857.

Pl. 14, figs. 13–16.

L. floribundum Dunal in DC. Prodr. **13**[1]: 513. 1852, not of

HBK; Miers, Ann. & Mag. Nat. Hist. II, **14**: 188. 1854, and Ill. S. Amer. Pl. **2**: 124, *pl. 70F.* 1857; Griseb. Abhandl. König. Ges. Wiss. Gött. **19**: 216. 1874 (Pl. Lorent. 168. 1874) and **24**: 245. 1879; Speg. Anal. Soc. Cient. Arg. (Nov. Add. Fl. Patag.) **53**: 170. 1902.

L. spinulosum Miers, Ann. & Mag. Nat. Hist. II, **14**: 191. 1854, and Ill. S. Amer. Pl. **2**: 127, *pl. 71D.* 1857.

L. spinulosum Miers var. *parvifolium* Gill. ex Miers, Ann. & Mag. Nat. Hist. II, **14**: 192. 1854, and Ill. S. Amer. Pl. **2**: 127. 1857.

L. microphyllum Philippi, Anal. Univ. Chil. **37**: 197. 1870, and Sert. Mend. Alt. 39. 1870 (not of Duham.).

L. minutifolium Philippi, Anal. Univ. Chil. **91**: 27. 1895 (not of Remy).

L. chubutense Dusén, Svensk. Exped. Magell. **3**[5]: 250, *pl. 9, figs. 1–2.* 1900.

L. Philippianum Speg. Anal. Soc. Cient. Arg. (Nov. Add. Fl. Patag.) **53**: 171. 1902.

L. floribundum α normale Terrac. Malpighia **4**: 530. 1891.

L. floribundum α normale var. *tenuispinosum* (Miers) Terrac. *l. c.* 531.

A sparingly branched, leafy, spiny, pubescent shrub 1–2 m. tall; branches horizontal or drooping, with many densely leafy, pungent-tipped branchlets, tan or gray, pubescent when young, spines slender, sharp; leaves linear-spatulate, 4–10 mm. long, 1 (2) mm. broad, densely tawny-pubescent, 3–7 in a fascicle, the nodes 3–7 mm. apart; flowers numerous, borne singly, the pedicels 1–2 (3) mm. long; calyx campanulate, tube 2–3 mm. long, lobes 5, lanceolate, rounded at apex, 2–4 mm. long, whole calyx covered with small glandular hairs interspersed with much longer multicellular flaccid hairs; corolla obconic-tubular, tubular portion 6 mm. long, nearly 3 mm. in diameter at the summit, 1–1.5 mm. in diameter at the base, glabrous without, lobes 5, ovate, about 3.5 mm. long (little more than half as long as the tube), slightly spreading, their margins very remotely ciliate; stamens 5, about equalling corolla-lobes, exserted when lobes are spreading, filaments subequal, about 2 mm. longer than corolla-tube, adnate to approximately midway on corolla-tube or slightly below or

above, pilose at base of free portion for 1 mm., adjacent corolla-tube also somewhat hairy, anthers 1.5–2 mm. long; style equalling or slightly exceeding stamens; berry ovoid, 3–4 mm. in diameter, several-seeded.

Type: collected at Mendoza, Argentina, by Miers (British Museum).

Distribution: western Argentina, from the Rio Negro to the Province of Mendoza.

Material seen:

ARGENTINA: Pampas, Jan. 1892, *Kuntze* (NY); Chubut, Trelew, Jan. 31, 1897, *Ameghino 8* (MBG); Puerto Madryn, Terr. Chubut, Patagonia Orientalis, Nov. 8, 1895, *Dusén 40* (KEW); Terr. Chubut, Peninsula Valdez, playa de Punta Norta, Dec. 30, 1912, *Exp. Roveretto* (MBG); vicinity of General Roca, Terr. Rio Negro, Sept. 1914–Feb. 1915, alt. 250–360 m., *Fischer 80* (F, G, KEW, MBG, NY, US); Buenos-Aires, *Bacle* (D); Rio Negro, Viedma, camino al faro, Nov. 14, 1928, *Castellanos* (MBG); Pinto, Prov. Santiago del Estero, Oct. 1892, *Kuntze* (NY); without locality, but probably from Mendoza, *Miers 735*, probably TYPE collection *L. tenuispinosum* (US); Carmenso, Prov. Mendoza, Nov. 5, 1928, *Parodi 8580* (G); Cordillera de Mendoza, *Bacle* (D); Mendoza, *Gillies* (KEW); "Buenos-Ayres (Mendoza)," *Balle* (D); Mendoza, *Gillies* (KEW TYPE collection *L. spinulosum* var. *parvifolium*); Vipos, Prov. Tucuman, Oct. 30, 1921, *Venturi 1384* (G, MBG, US in part, near the var. *Friesii*); Mendoza, coll. of 1876, *Philippi*, TYPE collection *L. microphyllum* (D, V), photograph of TYPE collection at Berlin (G, MBG); San Juan, Quebrada del Zonda, Feb. 28, 1926, *Castellanos* (MBG).

Lycium floribundum of Dunal is antedated by *L. floribundum* HBK., and *L. minutifolium* Philippi (a name Philippi gave to *L. microphyllum* when he realized that his specific name was preoccupied by *L. microphyllum* Loisel.) was preceded by *L. minutifolium* of Remy; *L. Philippianum* is a name proposed by Spegazzini for Philippi's species because of this fact.

14a. L. tenuispinosum Miers var. **Friesii** (Dammer) C. L. Hitchcock, comb. nov.

L. Friesii U. Dammer in Engl. Bot. Jahrb. **37**: 169. 1905.

Leaves spatulate, 5–12 mm. long, 2–3 mm. broad, glandular-pubescent; calyx glandular-pubescent, without long multicellular hairs intermixed, otherwise as in the species.

Type: Province of Salta, Argentina, Golgata in Quebrada del Toro in declivibus montis, apricis siccis, Nov. 11, 1901, alt. 2380 m., *Fries 664* (ST).

Distribution: From Prov. Mendoza to Prov. Jujuy, Argentina.

Materials seen:

Argentina: Maimara, Prov. Jujuy, May 13–15, 1873, *Lorentz & Hieronymus 744* (KEW), and *745* (D); Prov. Jujuy, Dept. Humahuaca, in declio petrosis, Feb. 20, 1901, alt. 2800 m., *Claren 11722* (ST); Prov. Tucuman, Dec. 1902, *Baer 113* (D); Prov. Salta, Golgata in Quebrada del Toro, loco aprico, Dec. 11, 1901, alt. 2380 m., *Fries 649* (ST); Prov. Salta, Golgata in Quebrada del Toro in declivibus montis apricis siccis, Nov. 11, 1901, alt. 2380 m., *Fries 664* (ST type); Argentine Republic, Oct. 1871, *Jameson*, in part (KEW); La Rioja, Sierra Vilgo, entre Cachiyuyal y Sañogasta, Feb. 5, 1928, *Castellanos* (MBG); Argentine Republic, Oct. 1872, *Jameson*, in part (KEW, V); Mendoza, Dec. 1906, *Carette* (MBG).

The variety *Friesii* approaches *L. ovalilobum*, and is almost intermediate between that species and *tenuispinosum* but the corolla and calyx resemble the latter, and the leaves are neither so thin nor so large as in the former.

14b. L. Venturii C. L. Hitchcock, sp. nov.[46] Pl. 23, fig. 2.

A rather sparsely and minutely pubescent shrub, scarcely, if at all, glandular; leaves spatulate, 5–12 mm. long, 3–4 mm. broad, thin in texture, rounded or acute at apex; flowers borne singly, pedicels 4–6 mm. long, minutely pubescent (glandular ?); calyx campanulate, minutely pubescent, tube about 3 mm. long, lobes 5, about equal to tube, lanceolate, acute; corolla narrowly tubular-

[46] **L. Venturii** C. L. Hitchcock, sp. nov., pubescens; foliis spatulatis, 5–12 mm. longis, 3–4 mm. latis; floribus solitariis, pedicellis 4–6 mm. longis, minute pubescentibus (glandulosis); calyce campanulato, pubescente, tubo 3 mm. longo, lobis 5, 2–3 mm. longis, acutis; corolla tubulo-infundibuliformi, tubo 7–8 mm. longo, extra glabro, lobis 5, 4 mm. longis, marginibus non ciliatis; staminibus 4–5 mm. exsertis, corollae tubi partem mediam adhaerentibus, basi villosis; stylo staminibus aequale; bacca ignota. Collected at Tucuman, Los Quemados, Oct. 1919, *Venturi 534* (Missouri Botanical Garden Herbarium, no. 997762 type).

infundibuliform, tube 7–8 mm. long, glabrous without, lobes 5, oval, about 4 mm. long, spreading, their margins not ciliate; stamens exserted 4–5 mm., filaments subequal, adnate to near middle of corolla-tube or above, pilose for 1–1.5 mm. above their free bases, adjacent corolla-tube also pubescent, anthers 1.25 mm. long; style about equalling stamens; fruit not seen.

Type: Prov. of Tucuman, Los Quemados, Argentina, Oct. 1919, *Venturi 534* (MBG).

Known only from the type collection.

The above plant resembles *L. tenuispinosum* var. *Friesii* in some respects, but is more like *L. Tweedianum* in others, the corollas being somewhat larger than in either. The calyx characters and pubescence of *L. Venturii* correspond with the former species, the flower shape, stamen length, and leaf characters more nearly agree with the latter; because of its intermediate nature, it is thought that *L. Venturii* may be a hybrid between the two.

15. L. ovalilobum C. L. Hitchcock, sp. nov.[47]

Pl. 14, figs. 29–31; pl. 22.

A rather densely branched, leafy, armed, spreading shrub, minutely glandular-pubescent; branches very leafy, long and slender, light brown, armed with sharp spines; leaves membranous-fleshy, obovate to oblanceolate, 1–3 cm. long, 0.2–0.6 cm. broad, rounded or slightly acute at apex, tapered to petiole as much as 1 cm. long in larger leaves, 1–5 in a fascicle; flowers usually borne singly, less commonly in 2's at the nodes, pedicels 1–4 mm. long; calyx-tube cup-shaped, 2–3 mm. long, nearly as wide, lobes 5, ovate to lanceolate, 3–5 mm. long, the whole rather minutely but densely glandular-pubescent with simple hairs; corolla white to yellowish, narrowly tubular-infundibuliform, tubular portion about 6 mm. long, 2 mm. in diameter at the top and 1 mm. in

[47] **L. ovalilobum** C. L. Hitchcock, sp. nov., fruticosum, ramosissimum, foliosum, spinosum, glandulosum, pubescens; ramis longis gracilibusque; folii stenuibus carnosulisque, obovatis vel oblanceolatis, 1–3 cm. longis, 0.2–0.6 cm. latis, 1–5-fasciculatis; calyce poculoforme, glanduloso-pubescente, tubo 2–3 mm. longo, lobis 3–5 mm. longis, ovatis vel lanceolatis; corolla candida vel subflava, tubo 6 mm. longo, 5-fido, lobis 2.5 mm. longis; staminibus 5, exsertis, corollae tubi partem mediam adhaerentibus, basi villosis; stylo 1–3 mm. staminibus longiore; bacca ignota. Collected in the Prov. of Catamarca, Dept. Andalgala, Argentina, Sept. 9, 1916, *Jörgensen 976* (Missouri Botanical Garden Herbarium, no. 818834 TYPE, G, US).

diameter at the base, 5-lobed, the lobes slightly spreading, ovate, nearly half as long as the tube (about 2.5 mm.), minutely pubescent at top of tube and on back of the lobes, their margins remotely ciliolate; stamens 5, about equalling corolla-lobes, filaments subequal, adnate to about middle of corolla-tube or slightly above, pilose for the first 2 mm. of their free portion, adjacent corolla-tube also somewhat pubescent, anthers 1.5 mm. long; style exceeding stamens from 1–3 mm.; berry not seen.

Type: Prov. Catamarca, Dept. Andalgala, Argentina, Sept. 9, 1916, *Jörgensen 976* (MBG).

Distribution: central and northern Argentina.

Material seen:

Argentina: El Dogue?, Prov. La Rioja, Dept. Capital, Dec. 26, 1928, *Venturi 7807* (G); Cerro del Remate, Dept. Pellegrini, Prov. Santiago del Estero, Dec. 21, 1927, alt. 550 m., *Venturi 5690, 5691* (CA); Gramilla, Prov. Santiago del Estero, Dept. Grimenez, March 13, 1930, alt. 300 m., *Venturi 10280* (MBG, ST); Prov. Catamarca, Dept. Andalgala, Sept. 9, 1916, *Jörgensen 976* (G, MBG type, US); shrub found abundantly in waste places about San Juan and Jachal, Prov. San Juan, Sept. 1872, *Jameson* (KEW); arid plains, San Juan and Jachal, Prov. San Juan, Sept. 1872, *Jameson* (KEW).

16. L. infaustum Miers, Ann. & Mag. Nat. Hist. II, **14**: 192. 1854, and Ill. S. Amer. Pl. **2**: 128, *pl. 71E.* 1857; Speg. Anal. Soc. Cient. Arg. (Nov. Add. Fl. Patag.) **53**: 170. 1902.

Pl. 14, figs. 26–28.

L. floribundum β infaustum (Miers) Terrac. Malpighia **4**: 531. 1891, in part.

A very much branched, rigid, spiny, glabrous shrub, 0.5–2 m. tall; branches heavy, usually well armed with sharp spines, rough, gray; leaves numerous, glabrous, fleshy, terete-spatulate, 3–5 (9) mm. long, 0.5–1 (4?) mm. broad, 2–6 in a fascicle, the nodes very close (2–4 mm.) together; flowers few, borne singly, pedicels 3–6 mm. long; calyx cup-shaped, glabrous, 2–3 mm. long, nearly as wide, more or less irregularly 4–5-lobed, the lobes very short, triangular; corolla narrowly tubular-infundibuliform, with spreading lobes, tubular portion (4.5–5) 6–7 mm. long, 2–3 mm. wide at

summit, glabrous without, lobes 5, oblong-ovate, spreading, 2.5–4 mm. long, margins not ciliate, or very sparsely so; stamens 5 (6), filaments attached about 3/5 way from base of tube, equal or very slightly subequal, about equal in length to corolla-lobes, hence stamens usually exserted 3–4 mm. when the lobes are reflexed, glabrous at base of free portion, but very densely hairy for about 1.5 mm. above this glabrous portion, corolla-tube pubescent between the bases of the free portion of the filaments, anthers 1.5 mm. long; style (not mentioned in Miers' description) exceeding stamens as much as 3 mm.; "berry red," globose or ovoid, several-seeded.

Type: near Rio Colorado and Bahia Blanca, south of Province of Buenos Aires, Argentina, *Tweedie* (British Museum).

Distribution: central Argentina.

Material seen:

ARGENTINA: without locality, Sept. 1871, *Jameson* (KEW); without locality, Sept. 1872, *Jameson* (KEW in part, G); Mendoza, Guanacache, March 10, 1926, *Castellanos* (MBG); Totoralejos, Prov. Cordoba, Nov. 1892, *Kuntze* (NY, US); La Rioja, Alpasinche, Feb. 17, 1930, *Castellanos* (MBG); Patagonia, south of Prov. of Buenos Ayres, near Rio Colorado and Bahia Blanca, *J. Tweedie* (KEW TYPE collection).

All the material placed in this species has flowers with corollas that are larger, in all respects, than those of the type collection, the flowers of that plant having a corolla-tube that is scarcely 5 mm. long, all other dimensions being correspondingly small. The flowers are identical with the bulk of the material above cited except for size; however, Miers gave 6 mm. as the corolla length, so there is probably a variation of one or two mm. in this respect.

Lycium infaustum differs from *L. Tweedianum* in having larger flowers, more spiny and densely branched stems, and smaller "ericoid" leaves. From *L. rachidocladum* and its allies, it differs in its short calyx-lobes, more slender corolla-tube, and longer stamens.

17. L. decipiens U. Dammer in Engl. Bot. Jahrb. **37**: 168. 1905.
Pl. 16, figs. 1–3.

A low, gnarled, spreading, pubescent, heavy shrub 2–4 dm. tall;

branches twisted, exceedingly thick and heavy, armed only by the pungent tips of the few short branchlets, much furrowed, dark gray; leaves 6–12 in a fascicle, linear, 7–10 mm. long, 0.5–1 mm. broad, margins usually revolute, covered with dense short hirtellous pubescence, greenish-cinereous, sessile; flowers numerous, borne singly, pedicels about 1 mm. long, exceedingly pubescent; calyx campanulate, 3.5–5 mm. long, densely pubescent with hairs nearly 0.5 mm. long (about 4 times as long as pubescence of leaves), 4-lobed, the lobes linear-lanceolate, acute, about equal to tube, often with red streaks on backs of lobes; corolla infundibuliform, contracted above ovary, tubular portion violet to lilac, 6.5–7.5 mm. long, about 3 mm. in diameter at top, 1.5 mm. in diameter at top of ovary, and 2 mm. at base, glabrous or with very few scattered hairs without, lobes 4 (5), very broadly ovate, 2 mm. or slightly less in length, apex rounded or slightly retuse, margins with very few hairs, glabrous or with few hairs on back, spreading; stamens 4 (5), partially exserted, filaments equal or but slightly subequal, somewhat enlarged at base, adnate to 1–2 mm. above base of the corolla, pubescent with long simple hairs for 3 mm. from base of free portion, adjacent corolla-tube apparently glabrous, anthers 1.25 mm. long; style 1–2 mm. shorter than stamens; ovary surmounted on well-developed disc, 10–18-ovuled; mature fruit not seen.

Type: hot, dry, rocky soil, Moceno, Prov. Jujuy, Argentina, Nov. 18, 1901, alt. 3500 m., *Fries 794* (ST).

Distribution: central and northwestern Argentina, from Prov. Jujuy to Prov. Catamarca.

Material seen:

Argentina: Corral Colorado, Sierra Famatina, Prov. de la Rioja, Feb. 11, 1879, *Hieronymus & Niederlein 772* (D); loco aprico sicco saxoso, Moceno, Prov. Jujuy, Nov. 18, 1901, alt. 3500 m., *Fries 794* (ST, type); from same locality, *Fries 783* (ST); Prov. Catamarca, Chashuil, Jan. 26, 1930, *Castellanos* (MBG) with some doubt; Chorrillos, Prov. Los Andes, Feb. 26, 1927, *Castellanos* (MBG).

Lycium decipiens is most closely related to, but quite distinct from, *L. ovalilobum* and its allies, differing in its four-lobed corolla, dwarf form, heavy, short branches, narrow leaves, and short

style, and in having its filaments adnate only near the base of the corolla-tube.

18. L. pubitubum C. L. Hitchcock, sp. nov.[48]

Pl. 15, figs. 19–21; pl. 23, fig. 1.

A densely leafy, spiny, sparsely pubescent shrub; branches apparently rigid, armed chiefly with the pungent tips of lateral branchlets; leaves borne in fascicles of 3–7 from enlarged nodes, glabrate, linear to spatulate, 8–12 mm. long, 1–2 mm. broad, apex rounded to acute, gradually attenuate to base; flowers borne singly at the nodes on glabrate pedicels 4–6 mm. long; calyx narrowly turbinate, 2.5–3.5 mm. long, 2 mm. in diameter at summit, tube glabrous, lobes 4, about ⅓ length of the tube, triangular, ciliate; corolla narrowly obconic, tubular portion 8–9 mm. long, 2.5–3 mm. in diameter at the summit, 1.8 mm. in diameter at base, slightly contracted and rather thickly pubescent with simple hairs just above ovary, rest of tube glabrous exteriorly, lobes 4, oblong, oval, 1.5–2 mm. long, spreading, their margins ciliate, otherwise glabrous; stamens 4, about equalling corolla-tube, filaments attached at point about ⅓ from base of corolla-tube, their free bases glabrate, densely pilose for 2 mm. above, adjacent corolla-tube also densely pubescent, anthers slightly more than 1 mm. long; style exserted 2–4 mm. from corolla-tube; ovary with several ovules, but mature fruit not seen.

Type: Argentina, Patagonia, 50° 30′, in 1882–84, *Moreno & Tonini 240* (NY).

Distribution: apparently known only from region of the type locality.

Material seen:

ARGENTINA: Patagonia, 50° 30′, in 1882–84, *Moreno & Tonini 240* (NY).

Lycium pubitubum is a very distinct species, well separated

[48] **L. pubitubum** C. L. Hitchcock, sp. nov., foliosum, spinosum, pubescens; ramis spinosis, foliis 3–7-fasciculatis, linearibus vel spatulatis, glabris, 8–12 mm. longis, 1–2 mm. latis; calyce turbinato, 2.5–3.5 mm. longo, tubo glabro, lobis 4, ca. 1 mm. longis, ciliatis; corolla tubulo-obconica, tubo 8–9 mm. longo, extra ad verticem ovarii pubescente, lobis 4, 1.5–2 mm. longis; staminibus corollae tubo aequalibus, corollae tubi partem tertiam inferam adhaerentibus, ad basem glabris, supra basem pubescentibus; stylo 2–4 mm. exserto; bacca ignota. Collected in Patagonia, Argentina, 50° 30′, in 1882–84, *Moreno & Tonini 240* (NY TYPE).

from the rest of the genus, but showing somewhat remote relationship with *L. decipiens*.

19. L. carolinianum Walt. Fl. Carol. 84. 1788; Michx. Fl. Bor. Amer. **1**: 95. 1803; Pursh, Fl. Amer. Sept. **1**: 97. 1814; Roem. & Schult. Syst. Veg. **4**: 697. 1819; Walp. Rep. Bot. Syst. **3**: 111. 1844; Dunal in DC. Prodr. **13**^{1}: 513. 1852; Miers, Ann. & Mag. Nat. Hist. II, **14**: 193. 1854, and Ill. S. Amer. Pl. **2**: 128, *pl. 71F*. 1857, in part; Gray, Proc. Amer. Acad. **6**: 45. 1862, in part, and Syn. Fl. N. Amer. ed. 2, **2**^{1}: 238. 1886, in part; Small, Fl. S. E. United States, 992. 1903. Pl. 15, figs. 30–32.

L. carolinianum α *normale* Terrac. Malpighia **4**: 518. 1891, in part.

Panzeria caroliniana Gmel. Syst. Nat. **2**: 247. 1791.

A rather sparingly branched, armed shrub, usually with few basal, and some upper branches, erect or slightly spreading, 0.3–1 m. tall, glabrous; young branchlets often with short, thick spines about 1 cm. long, or branchlets unarmed, older branchlets with spinose branchlets, tan to dark gray; leaves 3–10 in a fascicle, narrowly terete-spatulate to spatuloid, somewhat succulent, 1–2.5 cm. long, 1–2 mm. broad, midnerve scarcely visible, rounded, or occasionally somewhat acute at apex, attenuate at base, practically sessile, glabrous; flowers with pedicels 0.5–3 cm. long; calyx cup-shaped, glabrous, about 3 mm. long, 4-lobed, the lobes triangular, obtuse, nearly equalling tube, margins sometimes remotely ciliate; corolla lavender to purple, rotate-campanulate, 7–10 mm. long, including lobes, the tube about equal to lobes or slightly shorter, 1–1.5 mm. in diameter at top of ovary, 3–5 mm. in diameter at summit, glabrous without, lobes 4, rarely 5, ovate, base abruptly contracted, apex rounded or slightly emarginate, spreading, their margins not ciliate, or but very sparsely so; stamens exserted due to spreading of lobes of the corolla, filaments adnate to about midway from the base of the tube, equalling, or somewhat shorter than corolla-lobes, densely pilose on their lower ⅓ or ¼ of free portion, adjacent corolla-tube but very sparsely hairy, anthers 1–1.5 mm. long; style scarcely so long as filaments; berry ovoid, fleshy, red, about 1 cm. in diameter, with 50 or more seeds, purple in old or dried material.

Type: no type designated, but Curtiss's number 6543 is taken as typically representing this species.

Distribution: common throughout the coastal region of Florida and eastern portion of Alabama; Cuba and other islands of the West Indies.

Material seen:

United States of America

Florida: without locality, *Rolfs 240* (F, MBG); Anastasia Is., Aug. 1894, *Williamson* (PA); Gulf, Florida, *Chapman* (NY); Planters, June–July, 1898, *Hitchcock* (F); Vaca Key, June 22, 1904, *Brown 88* (PA); Grass Key, June 22, 1904, *Brown 97* (PA); Planters, April, 1903, *Hitchcock* (F); salt marsh, Myers, July–Aug. 1900, *Hitchcock 241* (F, G, MBG, NY, US); salt marshes, Myers, Jan. 26, 1896, *Webber 201* (F) and *201a* (MBG); Elliott's Key, Jan. 4, 1896, *Webber 324* (F, MBG); Elliott's Key, Nov. 6–7, 1901, *Small & Nash 227* (NY); Newport, Key Largo, March 26–29, 1898, *Pollard, Collins & Morris 182* (US); Key West, Monroe Co., coll. of 1874, *Palmer 377* (F, G, MBG); Key West, Feb. 28–March 9, 1904, *Lansing 2012* (NY); Key West, March 27–30, 1906, *Hitchcock* (F); Key West, Apr. 7–12, 1909, *Britton 517* (NY); Key West, *Blodgett* (F, NY, US); Key West, May, 1880, *F. Tweedie 211* (US); Dade Co., Nov. 7, 1903, *Eaton 52* (F); mangrove swamp, south of Miami, March 19, 1904, *Britton 62* (F, NY); on shore, Miami, Oct. 28–Nov. 28, 1903, *Small & Carter 1215* (NY, PA); Miami, Oct. 27–Nov. 13, 1901, *Small & Nash* (NY); borders of everglades, near Royal Palm Hammock, Dade Co., May 22, 1925, *E. J. Palmer 27481* (MBG); Marco, Collier Co., July–Aug. 1900, *Hitchcock* (F); Punta Rassa, Lee Co., July–Aug. 1900, *Hitchcock* (F); Sanibel, Lee Co., July–Aug. 1900, *Hitchcock* (F); vicinity of Fort Myers, Lee Co., Dec. 18, 1919, *Standley 18989* (US); vicinity of Fort Myers, creek banks, Dec. 21, 1916, *Miss Standley 374* (P, US); Boca Grande, Lee Co., Nov. 1913, *von Schrenk* (MBG); Shaw's Point (near Manatee), Oct. 22, 1898, *Simpson 88* (US); Clearwater, Pinellas Co., Jan.–Feb. 1902, *Huger* (NY); Brevard Co., Oct. 26, 1902, *Fredholm 5506* (G); crevice of coquina rock at edge of Indian River, Brevard Co., Oct. 10, 1894, *Swingle* (F); near Daytona, Volusia Co., Apr. 8, 1906, *Deam* (G); Cedar Keys, Levy Co., Oct. 1877, *Garber* (G,

US); Cedar Keys, Dec. 25, 1906, *Mell* (MBG); Cedar Keys, March 18, 1926, *Miller 327* (US); Cedar Keys, Oct. 1877, *Porter* (F); Cedar Keys, March 7, 1880, *J. D. Smith* (US); salt marshes, near mouth of St. John's R., Duval Co., Oct. 10, 1899, *Curtiss 6543* (C, D, G, MBG, NY, S, US); islands near mouth of St. John's R., *Curtiss 2216* (G, MBG, NY, US).

Alabama: wet gravelly beach, Westfouldivian?, Aug. 15, 1879, *C. Mohr* (US).

West Indian Islands: rocky parts of the landing place, Patos Is., June 9, 1929, *Broadway 7201* (MBG, US); Lomo de Loro, Cayo Romanio, Camaguey, Cuba, Oct. 21, 1909, *Shafer 2632* (F, G, NY, PA, US); border of saline plain, Guantanamo Bay, Oriente, Cuba, March 17–30, 1909, *Britton 2266* (NY); Bay of Mariel, Province of Pinar del Rio, Sept. 21, 1910, *Britton & Earle 7578* (F, NY, US), more spiny than Florida plants; Prov. of Santa Clara, Rio Govelan, March 26, 1910, *Britton, Earle & Wilson 6027* (NY).

Lycium carolinianum is usually found on tide land, or in the vicinity of pools near the ocean or a short distance inland. It is quite distinct from any other species of the American Lycia, being most closely related to *L. Tweedianum* and its variety *chrysocarpum* from which it may be distinguished by the larger, more ovate corolla-lobes.

19a. L. carolinianum var. quadrifidum (Moç. & Sessé ex Dunal) C. L. Hitchcock, comb. nov.

L. quadrifidum Moç. & Sessé ex Dunal in DC. Prodr. **13**[1]: 513. 1852 (based on Moçino and Sessé, Ic. Mex. Pl. *pl. 914*, acc. Dunal in DC. Prodr. *l. c.*); Hemsl. Biol. Cent.-Am. Bot. **2**: 426. 1882.

L. carolinianum Gray, Proc. Amer. Acad. **6**: 45. 1862, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 238. 1886, in part; Miers, Ann. & Mag. Nat. Hist. II, **14**: 193. 1854, and Ill. S. Amer. Pl. **2**: 128, *pl. 71F.* 1857, in part; Coult. Contr. U. S. Nat. Herb. (Bot. W. Tex.) **2**: 302. 1892; I. M. Johnst. Proc. Calif. Acad. Sci. IV. **12**: 1155. 1924; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1287. 1924.

L. carolinianum α normale Terrac. Malpighia **4**: 518. 1891, in part.

Leaves 2–5 in a fascicle, 1.8–3 cm. long, 2–4 mm. broad, midnerve plainly visible; branching, if any, mostly basal; flowers about 1 cm. long.

Type: based on *pl. 914* of Moçino & Sessé, Ic. Mex. Pl. acc. to Dunal in DC. Prodr. *l. c.* C. G. Pringle's number 4174, from "saline meadows bordering Lake Cuitzeo, Michoacan, Mexico, Aug. 8, 1892," is a plant which matches the plate well, and is good representative material of this well-marked variety.

Distribution: along the coasts of Mississippi, Louisiana, and Texas, in the United States; eastern Mexico, and at Lake Cuitzeo in Michoacan, at Sinaloa, and at San Jose del Cabo, Baja California.

Material seen:

United States of America

Mississippi: Sam Holmes Island, Mississippi Delta, Aug. 14, 1900, *Lloyd & Tracy 48* (NY).

Louisiana: in swamps, more or less saltish, Pointe à la Hache P. O., Plaquemines Co., Oct. 8, 1885, *Langlois* (S); Bayou fouters, Plaquemines Co., Aug. 1880, *Langlois 242* (F); Battledore Is., April 18, 1900, *Tracy & Lloyd 48* (MBG, US); low brackish prairies, Cameron, Cameron Parish, Sept. 13, 1915, *Palmer 8528* (MBG); vicinity of Cameron, Nov. 29, 1910, *McAtee 1907, 1908, 1909* (US).

Texas: without locality, *Callam* (NY); Oct. 1835, *Drummond 244* (D, G, NY); near headwaters of Indian Creek, Brown Co., Aug. 11, 1877, *Reverchon 684* (MBG); Green Island, June 23–29, 1922, *Tharp 1204* (US); near mouth of Pecos R., coll. of 1881, *Havard 161* (G); vicinity of Corpus Christi, Nueces Co., Oct. 24, 1913, *Rose 18063* (NY, US); Corpus Christi Bay, Dec. 1879, *Palmer 953* (G, US); Corpus Christi, Sept. 27, 1906, *A. H. Howell 285* (US); Corpus Christi, March 5–12, 1894, *Heller 1395* (NY, US); Santa Clara, June, 1851, *Lindheimer* (G, MBG); El Jardin, July 23, 1923, *Runyon* (MBG); Sand Point, Calhoun Co., Dec. 1918, *Drushel* (MBG); Galveston Is., Sept. 1841, *Lindheimer* (MBG), and Nov. 1842, *Lindheimer* (G); Galveston, Sept. 12, 1915, *Fisher 1741* (US); Galveston, Aug. 12, 1915, *Fisher 1740* (US); Galveston, March 15, 1928, *Benke 4588* (F); Galveston, Sept. 16, 1877, *Ward* (US); sandy seashore, Galveston, Aug. 8,

1902, *Reverchon 3242* (MBG); plains near Eagle Pass, Sept. 24, 1852, *Bigelow* (NY); Virginia Point, Apr. 15, 1899, *Bray 38* (US); Los Fresnos, Dec. 1, 1924, *Runyon 692* (US); Port Bolivar, Aug. 29, 1917, *Fisher 5161* (US); Bayshore near mouth of Cedar Bayou, Dec. 2, 1918, *Hanson* (NY); near Bloomington, May 19, 1924, *Schultz 2497* (CA); Rio Bravo, salt marshes near its mouth, Oct. 1853, *Schott 29* (NY); Brownsville, salty soil, in 1922, *Runyon 273* (US).

MEXICO

TAMAULIPAS: vicinity of Tampico, March 10–April 19, 1910, alt. 15 m., *Palmer 201* (US).

HIDALGO: Mexcaltitan, shallow lagoons, Oct. 30, 1926, *Mexia 1011* (CA, C, MBG, US).

MICHOACAN: saline meadows bordering Lake Cuitzeo, Aug. 8, 1892, *Pringle 4174* (C, CA, D, F, G, MBG, NY, PA, ST, US, V).

SINALOA: El Carrizo, coll. of 1925, alt. 800 m., *Ortega 6014* (US); along beach, vicinity of Mazatlan, Apr. 6, 1910, *Rose, Standley & Russell 14106* (NY, US); plains north of Mazatlan, Sept. 27, 1925, *Mexia 83* (C, CA).

BAJA CALIFORNIA: San Jose del Cabo, coll. of 1898, *Grabendorffer* (C), Nov. 25, 1902, *T. S. Brandegee* (C, S, US), Oct. 16, 1899, *T. S. Brandegee* (C, US); La Paz, Feb. 4, 1928, *Jones 24400* (P).

The variety *quadrifidum* is well set off from the species by the less numerous but much larger leaves, the larger flowers, and the more numerous spines, as well as by its definite geographic distribution.

19b. L. carolinianum var. **Gaumeri** C. L. Hitchcock, var. nov.[49]
Tall, somewhat scandent shrubs or tree-like forms 2–8 m. tall; leaves 15–30 mm. long, about 2.5 mm. broad, 1–4 in a fascicle, scarcely, if at all, armed; flowers 8–9 mm. long.

Type: Silam, Yucatan, *Gaumer 1248* (F).

Distribution: Yucatan, along the Atlantic coast, and at Lake Chichancanab.

[49] **L. carolinianum** var. **Gaumeri** C. L. Hitchcock, var. nov., arbusta vel arbores 2–8 m. alta; foliis 15–30 mm. longis, 2.5 mm. latis; floribus 8–9 mm. longis. Collected at Silam, Yucatan, *Gaumer 1248* (Field Museum, TYPE).

Material seen:

MEXICO: Silam, Yucatan, *Gaumer 1248* (F TYPE); Progresso, Yucatan, *Gaumer 23162* (F); Progresso, Apr. 6, 1865, *Schott 286* (F); Territorio Quintana Roo, Yucatan, Lake Chichancanab, *Gaumer 1351* and *2286* (F).

The notes accompanying the above specimens indicate that this is an unusually tall shrub or tree; however, the leaf characters and all details of the flower structure are identical with the species, so that it would not be feasible to consider it as specifically distinct.

19c. L. carolinianum Walt. var. **sandwicense** (Gray) C. L. Hitchcock, comb. nov.

L. sandwicense Gray, Proc. Amer. Acad. **6**: 44. 1862; Skottsberg, Nat. Hist. Juan Fernandez & Easter Island **2**: 496. 1928.

L. carolinianum β sandwicense (Gray) Terrac. Malpighia **4**: 518. 1891.

Almost devoid of spines; leaves 20–35 mm. long, 2.5–5 mm. broad; corolla 6–9 mm. long; filaments but sparsely pubescent at base of free portion.

Type: Sandwich Islands, Oahu, coll. by Wilkes Expl. Exped. of 1838–42, *Mann & Brigham 597* (G).

Distribution: Hawaiian Islands and Easter Island.

Material seen:

HAWAIIAN ISLANDS: Island of Oahu, coll. of 1838–42, *Mann & Brigham 597* (G TYPE, MBG); Island of Oahu, at Diamond Head, Apr. 8, 1895, *Heller 2093* (G, MBG); Kolia, Kanai, on rocky seashore, *Mann & Brigham 596* (G).

ISLAND OF PASCUA: seashore west of Mataveri, June 26, 1917, *Skottsberg 664* (G, ST, US).

In his original description, Gray indicated his doubt that this plant was native to the Hawaiian Islands, describing his type as having glabrate filaments. This condition the writer doubts, as other material examined from the same locality, and apparently identical with the type, has some pubescence at the base of the filaments, although not so much as is commonly found in the species and its mainland varieties. Aside from the smaller flowers and lack of spines, the type of *L. sandwicense* is an exact match

for much of the material of the variety *quadrifidum* (lacking the dense pubescence of the filaments), but resembles the species more closely in these two points.

20. L. Berlandieri Dunal in DC. Prodr. **13**[1]: 520. 1852; Miers, Ann. & Mag. Nat. Hist. II, **14**: 138. 1854, and Ill. S. Amer. Pl. **2**: 114. 1857; Gray, Proc. Amer. Acad. **6**: 47. 1862, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 239. 1886; Hemsl. Biol. Cent.-Am. Bot. **2**: 426. 1882; Coult. Contr. U. S. Nat. Herb. (Bot. W. Tex.) **2**: 302. 1892; Small, Fl. S. E. United States, 992. 1903; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1287. 1924.

Pl. 15, figs. 10–12.

L. Berlandieri α normale Terrac. Malpighia **4**: 520. 1891.

L. Berlandieri β Miersii Terrac. *l. c.*

L. senticosum Miers, Ann. & Mag. Nat. Hist. II, **14**: 138. 1854, and Ill. S. Amer. Pl. **2**: 114, *pl. 68D.* 1857.

L. stolidum Miers, Ann. & Mag. Nat. Hist. II, **14**: 191. 1854, and Ill. S. Amer. Pl. **2**: 126, *pl. 71A.* 1857.

A rather sparingly branched, glabrous or pubescent shrub 0.7–2.5 m. tall, armed with few needle-like spines at ends of young branches, or practically unarmed; branches somewhat crooked, decumbent, slender, silvery-gray to reddish; leaves glabrate, sometimes finely pubescent, linear to elliptic-spatulate, 1–2.5 cm. long, 0.1–0.25 cm. broad, rounded or sometimes acute at apex, 1–3 in a fascicle, the nodes rather distant, therefore branches sparingly leafy; flowers borne singly or in 2's, pedicels 3–20 mm. long; calyx cup-shaped, 1–2 mm. long and nearly as wide, 3–5-lobed, lobes equal and about ⅓ as long as tube, or unequal, the calyx frequently splitting nearly to base on one side, glabrous except for a small tuft of hair at the tip of each lobe, infrequently the whole calyx pubescent; corolla blue or pale lavender, tubular portion obconic-infundibuliform, much constricted immediately above calyx, 4–8 mm. long, 2–4 mm. in diameter at the summit, 1 mm. in diameter or less just above the calyx, glabrate without, sometimes with few scattered hairs just above and below the summit of calyx, lobes 4 or 5, $^1/_6$–$^1/_3$ the length of the tube, usually reflexed and sometimes recurved; stamens unequal or subequal, about equal to corolla-lobes, hence slightly exserted, rarely in-

cluded, filaments adnate to a point about ⅓ way from base of tube, hairy for the first ¼–⅓ of their free portion, adjacent corolla-tube but slightly hairy, anthers about 1 mm. long; style equalling or very slightly exceeding stamens; berry globose-ellipsoid, about 4 mm. in diameter, 8–30-seeded.

Type: Mexico, near Laredo, Feb. 1828, *Berlandier 1411* (De Candolle Herbarium).

Distribution: southern Texas, eastern New Mexico, and northern Mexico.

Material seen:

United States of America

Texas: western Texas, Aug. 1901, *Earle 650* (NY); Texas, *Buckley* (PA); Rio Pecos, W. Texas, Sept. 1881, *Havard 156* (G, PA); Tex. & Pacific RR., W. Texas, coll. of 1881, *Havard 157* (G); without locality, Apr. 1881, *Havard* (F, US); Bexar Co., *Jermy 66* (US); without locality, *Mex. Bound. Surv. 1028* (US); hills near Laredo, May 25, 1852, *Schott* (NY); western Texas, coll. of 1890, *Nealley* (F); San Ygnacia, Zapato Co., July 4, 1925, *Runyon 878* (US); foothills of Chenate Mts., Sept. 8, 1914, *Young* (MBG); Rio Grande, coll. of 1848, *Wright* (G); sandy plains, mouth of canyon on the Rio Grande, June 26, 1852, *Bigelow* (NY); Big Springs, May 20–23, 1899, *Bray 395* (US); lower part of Juniper Canyon, July 15–18, 1921, alt. 1100 m., *Ferris & Duncan 3145* (CA, MBG, NY, S); Eagle Pass, May 10–14, 1904, *Griffiths 6352* (MBG); Eagle Pass, Maverick Co., May, 1913, *Orcutt 6000* (MBG); Mt. Anthony, Franklin Mts., at Canutillo, El Paso Co., July 21, 1911, *Barlow* (F); Redford, Aug. 7, 1919, *Hanson 786* (G, US); near Capate Mt., W. Texas, Sept. 1883, *Havard 90* (G, US); Beeville, Sept. 19, 1906, *A. H. Howell 279* (US); near Brackettsville, July 2, 1917, *Munz 1424* (P); 6 mi. south of San Antonio, June 18, 1921, *Schultz 570* (US); near San Antonio, 1900–02, *Wilkinson* (MBG); San Antonio, Sept. 1879, *Ball 904* (G); 105 mi. s. w. of San Antonio, Sept. 1879, *Palmer 950* (G, US); dry calcareous banks, San Angelo, Tom Green Co., Oct. 25, 1916, *E. J. Palmer 11134* (MBG); Comstock, Vervalde Co., Oct. 9, 1917, *E. J. Palmer 12955* (CA, MBG); near Brownsville, coll. of 1895, *Townsend 3* (US); 12 mi. from Brownsville, on San Benito Rd., Cameron Co., *Ferris & Duncan 3210* (CA, MBG, NY, S);

Laredo, Feb. 1828, *Berlandier 1411*, TYPE collection (D TYPE, G, V); Laredo, June 1828, *Berlandier 1788* (G); Laredo, Feb. 1891, *Dodge 60* (US); between the Frio and Nueces Rivers, on the road to Laredo, Jan. 27–28, 1880, *Palmer 951* (G, MBG, NY, US); Laredo, on the Rio Grande, Aug. 1879, *Palmer 952* (G, PA, US); arroyos, Presidio del Norte, Aug. 4, 1852, *Bigelow* (NY); San Angelo, May 18–19, 1899, *Bray 344* (US); collected in expedition from western Texas to El Paso, New Mexico, May–Oct. 1849, *Wright 540*, TYPE collection *L. stolidum* (D, F, G, MBG, US); exp. from western Texas to El Paso, N. M., May–Oct. 1849, *Wright 542* (D, F, G, US); plains south of Luna Well, July 15, 1897, *Wooton* (US); Sheep Springs, July, 1880, *Rusby 306½* (C, US); E. Carancahua Pt., Jackson Co., Sept. 9, 1922, *Tharp 1414* (US); Keller's Point, Sept. 7, 1922, *Tharp 1635* (US).

NEW MEXICO: Pecos Valley, near Texas line, June 19, 1901, *Bailey 744* (US); New Mexico?, in 1852, *Wright* (G).

MEXICO

COAHUILA: Mts., 6 mi. east of Saltillo, July, 1880, *Palmer 956* (G, US); Saltillo, July 1–8, 1880, *Palmer 957* (F, G, US); near the city of Matamoros, Jan. 1836, *Berlandier 3022* (D, G, MBG, NY).

SONORA: Picu Pass, March 23, 1926, *Long 33* (US).

SAN LUIS POTOSI: coll. of 1878, alt. 2000 m., *Parry & Palmer 656½* (G).

NUEVO LEON: Carrizal, near Monterey, Jan. 1828, *Berlandier "no. 1426–166"* TYPE collection *L. senticosum*, but 2 plants on sheet, 1 not *Lycium* (G); Monterey, coll. of 1924, *Orcutt 1269* (US).

Lycium Berlandieri breaks up into several well-marked varieties or forms, some of which have previously been regarded as species; however, since these aggregates differ by minor characters only, they can be more consistently treated as varieties. *Lycium stolidum* and *L. senticosum* have correctly been regarded as conspecific with *L. Berlandieri* by all workers since their publication by Miers.

20a. L. Berlandieri forma **parviflorum** (Gray) C. L. Hitchcock, comb. nov.

L. parviflorum Gray, Proc. Amer. Acad. **6**: 48. 1862, and Syn.

Fl. N. Amer. ed. 2, 2[1]: 239, 437. 1886; Hemsl. Biol. Cent.-Am. Bot. **2**: 426. 1882; Woot. & Standl. Contr. U. S. Nat. Herb. (Fl. N. Mex.) **19**: 569. 1915.

L. Berlandieri δ barbinodum var. *parviflorum* (Gray) Terrac. Malpighia **4**: 522. 1891.

L. barbinodum Miers as treated by Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1288. 1924.

Branches stouter and more leafy than in the species, nodes frequently cottony; flowers smaller than in the species, 4–6 (8) mm. long.

Type: Sonora, Mexico, Sept. 1851, *Thurber 962* (G).

Distribution: central and southern New Mexico and southern Arizona, and states of Sonora, Coahuila, and San Luis Potosi, Mexico.

Material seen:

UNITED STATES OF AMERICA

NEW MEXICO: White Mts., Lincoln Co., July 20, 1897, *Wooton 173* (C, D, G, MBG, NY, P, S, US); White Sands, Dona Ana Co., Aug. 8, 1905, *Wooton* (US); along Tularosa Creek, Otero Co., Aug. 24, 1897, *Wooton* (US); White Sands, Otero Co., Aug. 24, 1899, *Wooton* (US); wash, 1 mi. west of San Miguel, Aug. 20, 1930, alt. 1200 m., *Fosberg S3875* (MBG); flats, southwest of Pyramid Peak, Aug. 1, 1930, alt. 1275 m., *Fosberg S3748* (MBG); Cuchillo, Oct. 21, 1909, alt. 1500 m., *Goldman 1789* (US); Florida Mts., Aug. 27, 1895, *Mulford 1049a* (US); 20 mi. northeast of Roswell, Chaves Co., June 14, 1930, alt. 1100 m., *Goodman & Hitchcock 1135* (MBG).

ARIZONA: Tucson Mts., Nov. 1902, *Griffiths 3463* (NY, US); hills in Sabino Canyon, near Tucson, March 14, 1930, *Eastwood 17745* (CA); Sweetwater, few miles west of Sacaton, *Harrison 1784* (SAC); S. H. Mts., March 31, 1930, *Peebles & Loomis 6774* (US).

MEXICO

SONORA: Buena Vista ranch, El Alamo, May 27, 1925, *Kennedy 7100*, intermediate between this form and *L. Andersonii* var. *Wrightii* (C, US); Sonora, Sept. 1851, *Thurber 962* (G TYPE, NY).

COAHUILA: La Ventura, Aug. 2–5, 1896, *E. W. Nelson 3904* (G, US); Torreon, Oct. 13–20, 1898, *Palmer 490* (D, F, G, NY, US);

Peña, Feb. 1905, *Purpus 1089* (C, NY); Saltillo, coll. of 1898, *Palmer 112, 247* (C, D, F, G, MBG, NY, US); mountains east of Saltillo, Apr. 1880, *Palmer 954* (G, PA, US).

San Luis Potosi: valley of San Luis Potosi, coll. of 1876, *Schaffner 1059* (G), Aug. 1871, *Schaffner* (G); region of San Luis Potosi, coll. of 1878, alt. 2300 m., *Parry & Palmer 654* (G, MBG), and *654½* (G); west of Monterey, *Gregg 199* (G, MBG).

The differences between the forma *parviflorum* and the species are almost intangible, but in general there is a tendency for the form to have more robust plants, and to have smaller and more numerous leaves.

20b. L. Berlandieri var. **longistylum** C. L. Hitchcock, var. nov.[50]
Pl. 15, figs. 7–9; pl. 18, figs. 1–3.

Branches flexuous, sparingly armed; leaves 8–25 mm. long, 1–3 mm. broad; corolla much expanded above, the 5 lobes ($1/5$) $1/3$–$1/2$ as long as the tube; stamens 1–3 mm. longer than corolla-lobes; style equal to, or exceeding the stamens 1–2 (6) mm.

Type: foothills of the Santa Catalina Mts., Arizona, July 28, 1881, *Pringle* (MBG).

Distribution: southern Arizona, known only from a few localities in the southeastern portion of the state.

Material seen:

United States of America

Arizona: foothills of the Santa Catalina Mts., July 28, 1881, *Pringle* (D, F, MBG type, NY, US, but not G); mountains of Arizona, coll. of 1881, *Pringle 176* (G, probably part of type collection); Table Top Mt., Aug. 16, 1930, *Harrison, Kearney & Fulton 7295* (MBG, P, US); San Tan Mts., May 13, 1926, *Peebles & Harrison 1853* (US); S. H. Mountains, March 31, 1930, *Peebles & Loomis 6761* (MBG, P, SAC, US) (style exserted 5–7 mm., stamens non-functional).

[50] **L. Berlandieri** var. **longistylum** C. L. Hitchcock, var. nov., glabrum, 1–2 m. altum; ramis restricte spinosis flexilibus, sed rectis; foliis 8–25 mm. longis, 1–3 mm. latis; corolla lata, infundibuliformi, 6 mm. longa, 5-fida, lobis ($1/5$) $1/3$–$1/2$ quamdiu tubo; staminibus corolla 1–3 mm. longioribus; stylo staminibus aequante vel 1–2 (6) mm. longiore. Collected in the foothills of the Santa Catalina Mts., Arizona, July 28, 1881, *C. G. Pringle* (Missouri Botanical Garden Herbarium, no. 127338 type, F, NY, US).

This variety is very well marked by the extremely long stamens and style, a condition which is made more conspicuous due to the recurving of the corolla-lobes.

20c. L. Berlandieri var. **peninsulare** (Brandg.) C. L. Hitchcock, comb. nov.

L. peninsulare T. S. Brandg. Univ. Cal. Publ. Bot. **6**: 359. 1916; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1288. 1924.

L. parviflorum var. *peninsulare* (Brandg.) I. M. Johnst. Proc. Calif. Acad. Sci. IV, **12**: 1154. 1924.

L. barbinodum Miers, Ann. & Mag. Nat. Hist. II, **14**: 138. 1854, and Ill. S. Amer. Pl. **2**: 115, *pl. 68E.* 1857; Gray, Proc. Amer. Acad. **6**: 47. 1862, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 239. 1886; Hemsl. Biol. Cent.-Am. Bot. **2**: 426. 1882.

Stems very leafy; leaves 10–30 mm. long, nodes sometimes cottony; flowers numerous, corolla 6–8 mm. long, the 4 (5) lobes ½ to nearly as long as the tube, reflexed; stamens about equal to, or slightly longer than corolla, much exserted.

Type: San Jose del Cabo, Baja California, coll. of 1899, *T. S. Brandegee* (C).

Distribution: Mexico, states of Baja California, Sonora, and Sinaloa.

Material seen:

Mexico

Baja California: Todos Santos, Dec. 14, 1928, *Jones 24111* (P), Jan. 28, 1890, *T. S. Brandegee* (C); Cape San Lucas, March 24, 1911, *Rose 16413* (NY, US); San Jose del Cabo, Jan 19, 1928, *Jones 24398* (MBG, P), coll. of 1898, *Grabendorffer* (C), Nov. 1902, *T. S. Brandegee* (C, US), coll. of 1899, *T. S. Brandegee* (C type), Nov. 1, 1899, *T. S. Brandegee* (C), Apr. 30, 1891, *T. S. Brandegee* (C), Sept. 16, 1890, *T. S. Brandegee* (C), Sept. 19, 1890, *T. S. Brandegee 417* (C); from Tres Pachitas to Valle Flojo, Dec. 25, 1905, alt. 700 m., *Nelson & Goldman 7350* (MBG, US); from Cerro Colorado to Rodriguez, Dec. 16, 1905, alt. 300 m., *Nelson & Goldman 7327* (US).

Sonora: hills and ravines, Guaymas, Sept. 1887, *Palmer 230* (C, G, NY, US); Hermosillo, Oct. 26, 1926, *Jones 22517* (MBG, P).

Sinaloa: San Blas, Feb. 1, 1927, *Jones 23102* (MBG, P); Monterey, coll. of 1878, *Parry 12* (G).

Without locality: northwestern Mexico, *Seemann*, type collection *L. barbinodum* (G, KEW).

The greatly reflexed lobes of the corolla and the large leaves are the important characteristics of this variety. Brandegee's type is a very close match for the type of *L. barbinodum.* Miers' plate of his species (*L. barbinodum*) does not match the type collection, and as Gray (*l. c.*) pointed out, neither does the plate match the description.

20d. L. Berlandieri var. **brevilobum** C. L. Hitchcock, var. nov.[51] Pl. 15, figs. 13–15.

Glabrate, practically unarmed; branches straight, leaves spatulate, 3–15 mm. long, 1–1.5 mm. broad, in fascicles of 2–5, these 2–7 mm. apart; pedicels 2–6 mm. long; corolla-tube funnelform, ½–1 mm. in diameter, abruptly flared at top, the 5 lobes 1 mm. long, not reflexed; stamens slightly exserted.

Type: Conception del Oro, Mexico, Aug. 11–14, 1904, *Palmer 285* (MBG).

Distribution: southern Texas and the neighboring state of Zacatecas, Mexico.

Material seen:

United States of America

Texas: Presidio del Norte, on the Rio Grande, *Bigelow* (NY); Upper Tarlinga Creek, W. Texas, Sept. 1883, *Havard* (F, US).

Mexico

Zacatecas: plains, Cedros, Aug. 1908, *Lloyd 137* (US); near Conception del Oro, Aug. 11–14, 1904, *Palmer 285* (C, F, MBG type, NY, US).

The following numbers are intermediate between the variety and the species: Uvalde, Uvalde Co., Texas, May 9, 1918, *E. J. Palmer 13537* (MBG); on mesa n. e. base of Quitman Mts., near

[51] **L. Berlandieri** var. **brevilobum** C. L. Hitchcock, var. nov., glabrum, minus spinosum; ramis rectis; foliis spatulatis, 5–15 mm. longis, 1–1.5 mm. latis, 2–5-fasciculatis; pedicellis 2–6 mm. longis; corollae tubo infundibuliformi, 0.5–1 mm. in diametro, ad verticem dilatato, lobis 1 mm. longis. Collected near Conception del Oro, Zacatecas, Mexico, Aug. 11–14, 1904, *Palmer 285* (Missouri Botanical Garden Herbarium, no. 127336 type, C, F, NY, US).

Sierra Blanca, Hudspeth Co., Texas, July 4, 1921, *Ferris & Duncan 2511* (CA, MBG, NY, S); Presidio, western Texas, coll. of 1881, *Havard 154, 155* (G, PA); mountains west of Saltillo, Coahuila, Mexico, Aug. 14–17, 1880, *Palmer 955* (G, PA, US).

This conspicuous little variety seems almost to deserve specific recognition, but because of the prevalence of so many intermediate forms and the undependability of the number of the corolla-lobes as a taxonomic criterion in this genus, it is perhaps best treated as a variety.

The following collections have peculiar narrow, pallid leaves, and a characteristic appearance, and should probably be distinguished from the species by some minor category, but because of lack of flowers on all material studied, the writer is loath to follow such a procedure.—

United States of America

Arizona: Fish Creek, Apache Trail, Oct. 29, 1928, *Eastwood* (CA); Catalina Mts., Sabino Canyon, Aug. 18, 1903, alt. 1000 m., *Jones* (MBG, US); San Tan Mts., Sept. 28, 1925, *Peebles, Harrison & Kearney 144* (US); Tucson, Laboratory Hill, June 21, 1904, *Coville 1896, 1897* (US); Tucson Mts., Oct. 1901, *Thornber* (US); Tucson Mts., near Tucson, Jan. 3, 1903, *Thornber 499* (US); Santa Rita Mts., Aug. 24, 1903, alt. 1500 m., *Jones* (P); fenced area, Santa Rita Forest Reserve, March 31–Apr. 23, 1903, *Griffiths 3908* (US); fenced area, Santa Rita Forest Reserve, Sept. 27–Oct. 4, 1903, *Griffiths 5955* (US); Santa Rita Range Reserve, Sept. 16, 1912, *Wooton* (US); Phoenix, May 6, 1903, alt. 300 m., *Jones* (P).

Mexico

Sonora: New Year's Mine, 20 miles from Hermosillo, Oct. 28, 1926, *Jones 22518* (P).

21. L. Richii Gray, Proc. Amer. Acad. **6**: 46. 1862; Syn. Fl. N. Amer. ed. 2, **2**[1]: 238, 437. 1886; Abrams, Fl. Los Angeles & Vic. 323. 1917; David. & Moxl. Fl. S. Calif. 321. 1923; I. M. Johnst. Proc. Calif. Acad. Sci. IV, **12**: 1153. 1924; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1287. 1924 (exclusive of *L. Pringlei*); Jepson, Man. Fl. Pl. Calif. 891. 1925, in part. Pl. 15, figs. 25–26.

L. Berlandieri β *Miersii* var. *Palmeri* subvar. *Richii* Terrac. Malpighia **4**: 521. 1891.

L. Palmeri Gray, Proc. Amer. Acad. **8**: 292. 1870, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 238. 1886; Hemsl. Biol. Cent.-Am. Bot. **2**: 426. 1882.

L. Berlandieri β Miersii var. *Palmeri* (Gray) Terrac. *l. c.*

L. cedrosense Greene, Pittonia **1**: 268. 1889; Standl. *l. c.* 1288, exclusive of *L. Andersonii* var. *pubescens.*

L. carolinianum β sandwicense var. *cedroense* Terrac. *l. c.* 518 (should be var. *cedrosense* (Greene) Terrac.).

An erect, spreading or somewhat clambering, much branched, spiny shrub 1–3 m. tall, sometimes forming rather dense thickets; branches tan, sometimes gray, pubescent when young, but soon glabrous, often flexuous, the spines thick, sharp; leaves elliptic, obovate, or more commonly, spatulate, 5–15 (30) mm. long, 3–10 mm. broad, acute to rounded, sessile to short-petiolate (1–2 mm.), glabrate to densely pubescent, thick and fleshy; pedicels 1–10 mm. long; calyx campanulate, glabrate or pubescent, 2–6 mm. long, 2–4 (6)-lobed, the lobes variable, from triangular and less than ½ as long as the calyx-tube, to linear or spatulate and as long as or longer than tube, the tube rather strongly angled from base to apex of each lobe; corolla-tube campanulate to tubular, pink or violet, often with black stripes in throat, 4–9 mm. long, 4-, less commonly 5–6-, lobed, the lobes spreading, oval, ⅓ as long to nearly as long as tube, margins sometimes slightly ciliolate; stamens about equal to corolla-lobes, hence usually exserted 3–5 mm. from corolla-tube, anthers about 1 (2) mm. long, filaments subequal, adnate to about midway on corolla-tube, sometimes slightly less, base of free portion nearly or quite glabrous, but densely pilose for 1–2 mm. just above this point, adjacent corolla-tube also hairy, but much less so below point of adnation; stigma equalling or slightly exceeding stamens; berry ovoid, 2-lobed, 4–6 mm. thick, with 30–50 seeds.

Type: La Paz, Baja California, *Major Rich* (NY).

Distribution: Colorado Desert and southern coast of southern California, southward the length of Baja California, and eastward to Sonora, Mexico.

Material examined:

United States of America

California: without locality, *Fitch* (NY); Colorado Desert,

sandy desert, Dos Palmas Spring, Riverside Co., Jan. 31, 1926, *Munz 9964* (P); Coyote Wells, Jan. 24, 1890, *Orcutt 2020* (MBG, US); Fig Tree John's, west shore of Salton Sea, March 19, 1917, *McGregor 2050* (S); Yaqui Well, western edge of Colorado Desert, Feb. 8, 1925, *Jaeger* (G, P); near Fish Traps, Imperial Co., Dec. 22, 1925, *Jaeger* (P); in arenis, Dos Palmas, March 30, 1922, *Spencer 2048* (MBG); Signal Mt., Imperial Co., Dec. 29, 1907, *Abrams* (G, NY, S); Palm Springs, Riverside Co., coll. of 1902, *Gilman 24*, suggestive of hybrid between *Richii* and *Andersonii* (C); Indio, Apr. 27, 1906, *Jones* (CA, P, S); Indio, June 10, 1907, *Bailey* (US); central part of Borrego Valley, western Colorado Desert, San Diego Co., Nov. 25, 1927, *J. T. Howell 3210* (CA, S); Borrego Spring, Apr. 19, 1906, *Jones* (P); Borrego Wells, San Diego Co., Apr. 13, 1913, *Eastwood* (CA); near Salton Sea, Colorado Desert, Feb. 25, 1927, *Feudge 1831* (P); San Clemente Is., Oct. 1902, *Trask 28* (US).

MEXICO

BAJA CALIFORNIA: without locality, *Diguet* (NY); northern Lower California, May 13, 1882, *Orcutt* (US); Lower California, Apr. 1882, *Parry* (G, MBG, S); Lower California, coll. of 1883, *Parry* (F, MBG); 10 kilom. n. of Ensenada, Sept. 12, 1929, *Wiggins & Gillespie 4011* (CA, MBG); Mulege, June 1887, *Palmer* (C, G, NY, US); near beach 5 mi. below Ensenada, alt. 2 m., March 29, 1925, *L. Ballou* (C, P); near Ensenada, Apr. 10, 1882, *Jones 3714* (CA, MBG, NY, P, S, US); south of Ensenada, July 5, 1922, *Fleming 1* (CA); near Colnet, Dec. 29, 1924, *Jones* (P); Pescadero, Nov. 1902, *T. S. Brandegee* (C, US); Isla Raza, Apr. 21, 1921, *Johnston 3215* (CA); Ildefonso Is., May 17, 1921, *Johnston 3747* (C, CA, G, MBG, NY, US); San Ramon, May 10, 1886, *Orcutt* (MBG); Comondu, Nov. 7, 1905, alt. 200 m., *Nelson & Goldman 7269* (MBG, US); Rosarito, Sept. 25, 1905, alt. 100 m., *Nelson & Goldman 7163* (US); Los Angeles Bay, May 6, 1921, *Johnston 3425* (CA); San Felipe Bay, Feb. 1904, *MacDougal* (NY); San Felipe (near sea-level), June 20, 1905, *Goldman 1163* (US); Magdalena Bay, coll. of 1925, *Mason 1918* (CA, NY, S); Magdalena Is., Jan. 13, 1889, *T. S. Brandegee* (C); Agua Verde, Apr. 1, 1911, *Rose 16586* (NY, US); San Francisquito Bay, Apr. 10, 1911, *Rose 16759* (NY, US); Cedros Is., June 4, 1925, *Mason 2014* (CA,

G); Cedros Is., Apr. 7, 1897, *T. S. Brandegee* (C); Cedros Island, Apr. 6, 1897, *T. S. Brandegee* (C); Cedros Is., March 10, 1911, *Rose 16108* (NY, US); La Paz, Feb. 3, 1906, *Nelson & Goldman 7487* (MBG, US); La Paz, Apr. 12, 1921, *Johnston 3061* (CA, G, US); La Paz, Nov. 8, 1926, *Jones 22516* (P); La Paz, Apr. 11, 1921, *Johnston 3027* (CA); La Paz, South. Calif., *Major Rich* (NY TYPE *L. Richii*, G); La Paz, Nov. 5, 1890, *T. S. Brandegee* (C); La Paz, June 14, 1897, *Rose 1310* (US); San Geronimo Is., March 15, 1897, *T. S. Brandegee* (US); San Quentin Bay, June 7, 1925, *Mason 2048* (CA); San Quentin, May 22, 1889, *T. S. Brandegee* (C); San Pedro Martir Is., Gulf of Mexico, Apr. 18, 1921, *Johnston 3154* (C, CA, G, NY, US); Isla Partida, Gulf of Mexico, Apr. 22, 1921, *Johnston 3233* (CA); San Jose del Cabo, Nov. 2, 1890, *T. S. Brandegee 418* (C, PA); San Martin Is., June 8, 1925, *Mason 2073* (CA); San Martin Is., Aug. 13, 1905, *Nelson & Goldman 7105* (US); San Martin Is., March–June, 1897, *Anthony 215* (C, G, MBG, US); San Martin Is., July–Oct. 1896, *Anthony 25* (F, G, MBG, NY, P, PA, US); Ascension Is., Apr. 17, 1897, *T. S. Brandegee* (C, G); Santa Rosalia, Feb. 24–March 3, 1889, *Palmer 183* (F, G, US); Santa Rosalia, Nov. 4, 1926, *Jones 22597* (P); All Saints' Bay, March 1882, *Parry & Pringle* (G); All Saints' Bay, Jan. 8, 1883, *Parry 12* (G); All Saints' Bay, May, 1882, *Fish* (G); Todos Santos Is., March 9, 1897, *T. S. Brandegee* (C).

Sonora: Yaqui River, coll. of 1869, *Palmer*, TYPE collection *L. Palmeri* (G TYPE, NY, US); Libertad, Oct. 15, 1923, *MacDougal & Shreve 21* (US); island in harbor, Guaymas, March 10, 1910, *Rose, Standley & Russell 12558* (NY, US); Guaymas, June 5–11, 1897, *Rose 1256* (US); alkali bottoms, Guaymas, June, 1887, *Palmer 71* (G, NY).

Sinaloa: without locality, coll. of 1925, *Ortega 5561* (US); Altata, vicinity of Culiacan, Sept. 2, 1904, *T. S. Brandegee* (G); Altata, June 15, 1897, *Rose 1341* (G, NY, US).

The type is very similar to most of the material from the vicinity of La Paz, and matches the plant collected at Magdalena Bay, Lower California, in 1925, by H. L. Mason, no. 1918. The calyx-lobes are about equal to the tube, or may be much shorter, there being much variation in this plant in this respect. The corolla is

usually 4-lobed, and is much expanded near the summit in some instances.

As cited above, the species includes plants showing a wide range of variation. The length of the calyx-lobes, elsewhere usually a fairly constant character in the genus, varies greatly here, as does the length of the corolla-lobes. In spite of the variation within the group, it is not difficult to distinguish *L. Richii* from other members of the genus, as the spatulate fleshy leaves and the long oval corolla-lobes are distinctive. The linear or spatulate calyx-lobes, when present, immediately place the plant in this species, as the only other North American species having lobes that are at all similar are *L. macrodon* and *L. Parishii*, but the fruit of the former and the corolla of the latter cannot be confused with this species. The dense mass of hairs near the base of the free portion of the filaments, and the coastal range are also of help in placing plants in this species.

In general, the material from the islands off the coast of southern California has much longer calyx-lobes than that from Lower California, and the plants are more slender, with a tendency to be clambering. There appears to be sufficient difference to maintain these plants as a variety. Where plants with this type of corolla merge with those of Lower California (forms with much shorter calyx-lobes) there is every degree of intergradation. All evidence indicates that there are many local strains developed throughout the range of the species, some of which may be considered to be geographic entities, the insular forms constituting the variety *Hassei* being the most striking example. Plants from the Colorado Desert, while having calyx-lobes nearly as long as those of the variety, are much more compact and have longer pedicels. Those plants growing in the northern portion of Lower California are sometimes densely pubescent; therefore, if the extreme cases only were taken into consideration it would be possible to split the group into about four varieties.

Although the type of *L. cedrosense* has not been seen, the description indicates that the species belongs with this group. The "sharp angle running from base of tube to the apex of each of the 5 broad-triangular teeth" fits the material of *L. Richii* from Cedros Island. The plant collected on this island June 4, 1925, *Mason*

2014, matches the description of *L. cedrosense* very closely, but falls well within the range of variation of *L. Richii*, the calyx-lobes, leaves, pubescence, corolla-lobes, and fruit all indicating this relationship.

Johnston[52] stated that *L. brevipes* and *L. cedrosense* are the same species. Were this definitely proven, the name *L. Richii* would have to be replaced by that of *L. brevipes*. It seems to the writer, however, that there is not sufficient evidence to warrant such a change, as Bentham's description is not adequate to merit such a conclusion, and the evidence from Miers'[53] description and plate of the same plant is not enough to make such identity certain, the calyx and the corolla-lobes being too small. Therefore, it is not deemed advisable to replace the name *Richii*, which is well established and understood.

In discussing the relationships of *L. Richii*, Johnston expressed his belief that the species is most closely related to *L. californicum;* however, the fruits of the two species are so totally unlike that it is certain that their relationship must be exceedingly distant.

21a. L. Richii var. **Hassei** (Greene) I. M. Johnst. Proc. Calif. Acad. Sci. IV, **12**: 1154. 1924; Jepson, Man. Fl. Pl. Calif. 891. 1925, in part. Plate 15, figs. 22–24.

L. Hassei Greene, Pittonia **1**: 222. 1888.

L. carolinianum γ *californicum* forma *Hassei* (Greene) Terrac. Malpighia **4**: 518. 1891.

L. Richii Gray in Bailey, Cycl. Hort. **4**: 1930. 1916; Millsp. & Nutt. Fl. Santa Catalina Island, 218. 1923.

Plant as much as 6 m. tall, almost unarmed; branches slender, flexuous; leaves glabrate or sparsely pubescent; calyx-lobes 1–3 times as long as the tube, spatulate.

Type: Santa Catalina Island, Los Angeles Co., California, July 15, 1888, *Hasse & Lyon* (Herbarium Greeneanum, at Notre Dame University).[54]

Distribution: islands off the coast of southern California, and from Santa Barbara and Los Angeles, where it is almost certainly

[52] Johnst. Proc. Calif. Acad. Sci. IV, **12**: 1154. 1924.

[53] Miers, Ill. S. Amer. Pl. **2**: 117, *pl. 69C*. 1857.

[54] The presence of this type in the Greene Herbarium was verified by Mr. Theodor Just, Assistant Curator there.

cultivated; from San Diego, where it may occur as a member of the native flora. Possibly now extinct as a native plant.

Material seen:

UNITED STATES OF AMERICA

CALIFORNIA: Isthmus, Catalina Is., July 6, 1909, *Pendleton 1421* (C, F); Catalina Is., Sept. 15, 1894, *Toumey 487* (F); Santa Catalina Is., Sept. 15, 1894, *Toumey* (C, NY); Catalina Is., June, 1886, *Trask 500* (F); Avalon, Santa Catalina Is., Apr. 1896, *Trask* (US); Avalon, Santa Catalina Is., June, 1896, *Trask* (NY); Avalon, Santa Catalina Is., Nov. 1896, *Trask* (C, MBG); Santa Catalina Is., May, 1889, *T. S. Brandegee* (C, P); Avalon, dry wash, March 30, 1900, *Grant 12469* (S); Catalina Is., Apr. 21–26, 1904, *Grant & Wheeler 739a/6151* (C, S); Santa Catalina Is., *Greata 6157* (C); Catalina Is., July 15, 1888, *Hasse 4155* (F); Santa Catalina Is., July 15, 1888, *Hasse*, probably TYPE collection (G, NY, S, US); Santa Catalina Is., Dec. 1895, *Hasse* (S); Avalon, Santa Catalina Is., *Knopf 509* (F); Avalon, Santa Catalina Is., Sept. 8, 1893, *McClatchie 514* (F); Santa Barbara, Oct. 1923, *Walther* (CA); Blakesley Garden, Santa Barbara, Aug. 12, 1930, *Hoffmann* (SBM); Exposition Park, Los Angeles, Aug. 1916, *Eastwood* (CA); San Diego, July, 1895, *Stokes* (S). The following collections are very close to the var. *Hassei*, although not typical—San Diego, June 17, 1918, *Mrs. T. S. Brandegee 907* (F, G, NY, P); dunes by sea, San Clemente Is., June, 1903, *Trask 331* (NY, US); San Clemente Is., June, 1903, *Trask 332* (NY, US).

22. L. verrucosum Eastwood, Proc. Calif. Acad. Sci. III, **1**: 111. 1898; David. & Moxl. Fl. S. Calif. 321. 1923. Pl. 16, figs. 4–6.

An intricately branched, compact, sparingly spinescent shrub 1–3 m. tall; branches short, heavy, armed with few thick, blunt spines, dull tan, scurfy-pubescent, soon becoming glabrous; leaves scurfy-pubescent, spatulate, 5–10 mm. long, 3–6 mm. broad, contracted rather uniformly at the base, short-petioled; pedicels 4–8 mm. long, pubescent; calyx campanulate, about 4 mm. long and ½ as wide, irregularly 3–4-lobed, the lobes narrowly lanceolate, not quite equalling the tube, pubescent; corolla lavender, tubular, narrow, slightly contracted above the ovary, 8–10 mm. long, 4–5-lobed, the lobes about ¼ as long as the tube, spatulate, sparsely

ciliolate; stamens 3–5, filaments short, adnate to the tube of the corolla and to the basal portion of the corolla-lobes, glabrous, but adjacent upper portion of the corolla-tube hairy, anthers small, less than 1 mm. long; style slightly exceeding the stamens, the stigma thus sometimes slightly exserted beyond the corolla-lobes; ovary with 25–40 ovules, "immature fruit reddish."

Type: San Nicholas Island, California, "on arroyo cliffs, several localities," April, 1897, *Blanche Trask* (CA).

Distribution: known only from the type locality.

Material seen:

United States of America: San Nicholas Is., California, Apr. 1897, *Trask*, type collection (CA type, MBG, US); on arroyo cliffs, San Nicholas Is., Apr. 1897, *Trask 60* (MBG, but not G).

In her description, Miss Eastwood places this species near *L. californicum*, but there seems to be only remote relationship with that species. The flowers of *L. verrucosum* are larger and the corolla-lobes are only about one-fourth as long as the tube, whereas in *L. californicum* they are equal to or but slightly shorter than the tube; furthermore, the latter species always has a four-lobed corolla.

The writer considers *L. verrucosum* to be very close to *L. Richii*, both species having much the same type of calyx, corolla, leaves, and "branches" which are "verrucose at leaf axils from downy tufts at base of petioles." The points of dissimilarity are the spatulate lobes of the corolla, the amount of pubescence within the corolla-tube, and the point of attachment of the anthers. It is a very peculiar species, and one of which the status is not at all clear. Some of the anthers, at least, appear to be sterile. Perhaps it is because the plants grow "in inaccessible erosions along the arroyos" that more collections have not been obtained; but the writer is inclined to believe that the plant which Miss Trask collected was a freak which had its origin from seeds of *L. Richii*, and that this plant was the only one of such a nature.

23. **L. elongatum** Miers, Ann. & Mag. Nat. Hist. II, **14**: 136. 1854, and Ill. S. Amer. Pl. **2**: 112, *pl. 68A*. 1857; Griseb. Abhandl. König. Ges. Wiss. Gött. **19**: 217. 1874 (Pl. Lorent. 169. 1874).

Pl. 16, figs. 7–9.

L. elongatum var. *riojana* Hieron. ex Haum.-Merck, Anal. Mus. Nac. Buenos Aires **24**: 416. 1913.

L. confertum Miers, Ann. & Mag. Nat. Hist. II, **14**: 137. 1854, and Ill. S. Amer. Pl. **2**: 113, *pl. 68 C.* 1857.

L. floribundum β infaustum var. *elongatum* (Miers) Terrac. Malpighia **4**: 531. 1891.

L. floribundum β infaustum var. *confertum* (Miers) Terrac. *l. c.*

A rather intricately branched, well-armed, rigid shrub 1–2 m. tall; branches slender but not flexuous, well armed throughout, tan, fairly smooth, pubescent only when young; leaves 2–5 in a fascicle, linear to linear-spatulate, thin, 6–20 mm. long, 0.5–1.5 (3) mm. broad, glabrous, or less commonly minutely pubescent, rounded at apex, base long-attenuate; flowers few, borne singly at the nodes on pedicels 1.5–3 (4) mm. long; calyx very slender, cup-shaped, tube 2–3 mm. long, ½–⅔ as broad, with 5 slender, acuminate lobes nearly equal to or rarely longer than the tube, glabrous or sparingly pubescent on the surface, margins densely white-ciliate; corolla very narrowly obconic, tube contracted above ovary, about 8 mm. long, 2 mm. in diameter at the summit, glabrous exteriorly (or with band of persistent hairs near base), lobes 5, about 1 mm. long, oblong-ovate, spreading, glabrous except for few cilia on their margins; stamens included, filaments decidedly unequal, long ones nearly equalling corolla-tube, shortest one scarcely half this length, adnate nearly ⅔ the length of the corolla-tube, sparingly short-pilose for about 1 mm. of their free portion, corolla-tube also pubescent between filament-bases and for nearly 2 mm. below this point, especially along the vascular strands running to the filaments, anthers scarcely 1 mm. long; style equalling longest stamens; berry ovoid, 3–4 mm. long, 8–10-seeded.

Type: in desertis salsuginosis intra Cordovam et Santiago de Tucuman, Argentina, *Tweedie 1212* (British Museum).

Distribution: central and northern Argentina.

Material seen:

ARGENTINA: without locality, coll. of 1880, *Hieronymus* (US); Cajon del Rio Loro, Prov. Tucuman, Dept. Burruyacu, Jan. 12, 1924, *Venturi 2501* (C); Vipos, Prov. Tucuman, Oct. 30, 1921, *Venturi 1384* (US, in part); Tucuman, Tapia, Oct. 10, 1920, *Ven-*

turi 968 (MBG); Pinto, Prov. Santiago del Estero, Oct. 1892, *Kuntze* (NY); Altos Oeste Cordoba, May 9, 1897, *Stuckert 2799* (D); "El Charco," Prov. Santiago del Estero, Oct. 25, 1929, *Venturi 9702* (G, MBG); Cordoba, San Javier, July, 1922, *Hauman* (MBG); Cordoba, *Kuntze* (NY); Cordoba, Nov. 23, 1880, *Hieronymus* (D); Estancia Germania pr. Cordoba, June–Dec. 1874, *Lorentz 30* (D); Cordoba, Oct. 1871, *Lorentz 131* (G); Cordoba, coll. of 1873, *Lorentz & Hieronymus* (NY); Cordoba, Dec. 16, 1880, *Galander* (KEW); Puebla Cordoba, June 1, 1913, *Curran 95* (US); La Rioja, General Roca, San Francisco, July 16, 1928, *Gomez* (MBG).

As Miers pointed out, the corolla of *L. elongatum* resembles that of *L. cestroides* in some respects. However, the corolla-lobes are much less pubescent, and the leaf character alone is sufficient to distinguish the two. From Miers' description and plate, it seems certain that *L. confertum* is only a variation of *L. elongatum*—material examined has leaves much like that pictured for the former species. The linear-lobed calyx, narrow, 5-lobed corolla with unequal, included stamens adnate above the middle of the tube, and the pubescence on the corolla-tube below the point of adnation of the filaments are all very striking characters and make a decidedly unusual combination, yet they are common to both of his species. In fact, the only difference he shows is the narrower leaves and external pubescence on the corolla of *L. confertum.* None of the material examined has this pubescence, but notwithstanding, it seems certain that the two species are very closely related, if not conspecific, and they are therefore treated as identical. It might be noted that Miers described *L. confertum* as having a calyx-tube three-fourths of a line long with segments one and one-fourth lines long, but his plate shows a calyx with lobes scarcely as long as the tubular portion.

Hieronymus[55] described a hybrid between *L. cestroides* and this species. Careful examination of one of his plants of this supposed hybrid nature (Cordoba, pr. urbem, Nov. 23, 1880) seems to indicate that he was correct in his deductions. The supposed hybrid has oblong-oblanceolate leaves 2–3 cm. long, 4–6 mm. broad (intermediate between *L. cestroides* and *L. elongatum*), the corolla-

[55] Hieronymus, Bol. Acad. Cienc. Cord. 4^1: 1, *figs. 1–16.* 1881.

lobes are much more ciliate than in *L. elongatum*, although not tomentose as in *L. cestroides*, the calyx is that of *L. elongatum*. On the whole, due largely to the spiny nature of the plant, it resembles *L. elongatum* and was so labelled by Hieronymus when collected; however, the leaves are so unlike that species and the other characters are so nearly intermediate between the two supposed parents that it is reasonable to regard it as a hybrid.

Other collections of this nature are: Cordoba, Argentina, Feb. 18, 1881, *Hieronymus* (NY); Cordoba, Argentina, Dec. 15, 1880, *Hieronymus* (D, KEW, NY); Estancia Germanica prope Cordoba, June–Dec. 1874, *Lorentz 30* (V).

24. L. minutifolium Remy in Gay, Hist. Chil. Bot. **5**: 93. 1849, not Philippi; Miers, Ann. & Mag. Nat. Hist. II, **14**: 134. 1854, and Ill. S. Amer. Pl. **2**: 110. 1857; Reiche, Anal. Univ. Chil. **123**: 396. 1908, and Fl. Chil. **5**: 316. 1910. Pl. 16, figs. 16–20.

L. chilense β rachidocladum var. *minutifolium* (Remy) Terrac. Malpighia **4**: 529. 1891.

L. implexum Miers, Ann. & Mag. Nat. Hist. II, **14**: 133. 1854, and Ill. S. Amer. Pl. **2**: 109, *pl. 67E*. 1857.

L. chilense γ implexum (Miers) Terrac. *l. c.* 530.

L. horridum Philippi, not Thunb., Fl. Atac. 43. 1860 (judging from description).

L. chilense α normale var. *deserticum* Terrac. *l. c.* 528, in part, as to *L. horridum* Phil.

L. crassispina Philippi, Anal. Univ. Chile **91**: 25. 1895; Reiche, Anal. Univ. Chil. **123**: 397. 1908, and Fl. Chil. **5**: 317. 1910.

L. pachyclados Philippi, Anal. Univ. Chil. **91**: 26. 1895 (judging from description only).

L. Rhudolphi Speg. Anal. Soc. Cient. Arg. (Nov. Add. Fl. Patag.) **53**: 168. 1902.

A very much branched, stout, spiny, pubescent shrub 0.5–1.5 m. tall; branches very numerous, thick, rigid, brownish-tan, spines confined chiefly to ends of branchlets; leaves elliptic to linear-spatulate, 2–10 mm. long, 0.5–2 mm. broad, somewhat succulent, more or less hirtellous, greenish or cinereous, 1–5 in a fascicle, the nodes very close together; flowers borne singly, pedicels 1–4 mm. long; calyx cup-shaped, 2–3 mm. long, irregularly

4-lobed, the lobes short, seldom over 0.5 mm. long, pubescence same as on the leaves, margins of lobes more thickly beset with hairs; corolla very narrowly tubular-obconic, glabrous without, tubular portion (7) 9–12 mm. long, 2.5 mm. in diameter at the summit, 1–1.5 mm. wide at top of ovary, lobes 4, spreading or recurved, ovate, 1–1.5 mm. long, their margins not ciliate; stamens usually exserted 1.5–2.5 mm. from corolla-tube, filaments adnate to about ⅓ way from base of corolla-tube, subequal, hairy for about the first 4 mm. of their free portion, corolla-tube also pubescent for 1–2 mm. below the point of adnation, anthers 1–1.5 mm. long; style longer or somewhat shorter than the stamens; mature fruit not seen, but ovary with several ovules.

Type: Prov. of Coquimbo, Chile, coll. of 1838, *Gay* (Paris).

Distribution: dry interior valleys of the Cordilleras of Chile, from Coquimbo northward to Atacama.

Material seen:

Chile: Prov. Coquimbo, coll. of 1838, *Gay* (MBG, photograph of type at Paris); Coquimbo, *Bridges 1334*, type collection *L. implexum* (KEW); Cord. Copiapo, Nov. 1863, alt. 3000 m., *Pearce* (KEW); Atacama, Feb. 1888, *Philippi* (KEW); Sierra San Miguel, Prov. Atacama, Dept. Copiapo, upper part of Quebrada San Miguel, Oct. 8, 1925, alt. 2400 m., *Johnston 4934* (G); vicinity of Potrerillos, lat. 26° 27′ S, long. 69° 30′ W, Oct. 23, 1925, alt. 2600 m., *Johnston 4706* (G, ST); Calpichi, Varas in des. Atacama, *Philippi* (V).

The type of *L. implexum* agrees very well with a photograph of the type of *L. minutifolium* at Paris; this evidence, coupled with the fact that the descriptions of the two plants are very much alike, makes it seem certain that the two are conspecific. *Lycium implexum* is the same, in all respects, as collections compared with the type of *L. crassispina* by Dr. I. M. Johnston, and pronounced conspecific with that species. So far as the writer can judge, *L. pachyclados* and *L. horridum* of Philippi, not Thunberg (*L. Rhudolphi* Spegazzini) belong here. Reiche placed *L. Chanar* under *L. crassispina,* and on one of the sheets which Dr. Johnston compared with Phillippi's types he has indicated that he considers that *L. horridum, L. pachyclados, L. Chanar,* and *L. crassispina* are very similar, if not identical; however, the original description of *L.*

Chanar gives the length of the corolla-tube of that species as "5½–6 mm.," a character which, if correct, practically precludes the possibility of *L. Chanar* being the same as *L. minutifolium.*

The following plants differ from the foregoing collections somewhat, the corolla being but 7 mm. long and the stamens being slightly shorter than the corolla-tube:

CHILE: Prov. Atacama, Dept. Chañaral, Quebrada de Portrerillos, along old road between Encanche and town of Portrerillos, Oct. 22, 1925, alt. 2400 m., *Johnston 3662* (G); Sierra San Miguel, Quebrada Salto below Portezuelo de San Pedrito, Prov. Atacama, Dept. Copiapo, Nov. 5, 1925, alt. 3100 m., *Johnston 4866* (G); Prov. Atacama, Dept. Copiapo, Cord. Rio Figueroa, Co. Paredones, Jan. 1926, alt. 3200 m., *Werdermann 980* (C, CA, F, G, KEW, MBG, ST). They resemble the species so closely in general appearance, however, that the writer hesitates to give them varietal rank, although there appears to be some basis for such a procedure.

25. L. distichum Meyen, Reise um die Erde **1**: 448. 1834 (footnote). Pl. 16, figs. 24–26.

L. (*Grabowskia*) *distichum* Nees, Nov. Act. Acad. Caes. Leop. **19**, suppl. 1: 389. 1843.

L. scabrum Nees, *l. c.* ?

L. oreophilum Wedd. Chlor. And. **2**: 108. 1857.

L. leiostemum Wedd. *l. c.*

L. divaricatum Rusby, Bull. N. Y. Bot. Gard. **8**: 117. 1912.

An open, much-branched, spiny, pubescent shrub, as much as 3 m. tall; branches rather slender, densely pubescent, tan in youth, glabrous and brown with age, spines slender, sharp, numerous on young shoots, older branchlets almost unarmed except for pungent apex; leaves oblong-ovate to linear-spatulate, rounded to acute, densely though minutely pubescent and mealy-glandular, 4–12 mm. long, 1–3 mm. broad, rather thick and apparently not fleshy, midnerve prominent, those at base of branchlets most commonly of the ovate type, borne singly or in 2's, those of younger branchlets and at apex more commonly approaching the linear-spatulate form, 1–3 in a fascicle, old nodes much enlarged; flowers few, borne singly at the nodes, pedicels 4–7 mm. long;

calyx campanulate, 3–4 mm. long, sparsely pubescent, the 5 lobes lanceolate, acute, about equal in length to the tube, sparsely ciliate, sinuses rounded; corolla obconic-tubular, tubular portion 11–13 mm. long, about 3 mm. in diameter at the apex, 1.5–3 mm. at base, pubescent externally in region of calyx-lobes, lobes (4) 5, partially erect or somewhat spreading, rounded, about 1.5 mm. long, margins not ciliate; stamens equal to corolla-tube or slightly longer, but usually appearing included due to ascending nature of corolla-lobes, filaments nearly equal, adnate below the middle of corolla-tube, pilose for 2 mm. above the adnate portion, corolla-tube pubescent also for 4 mm. below this free portion, especially along the vascular traces of the filaments; style equalling stamens, stigma nearly 1 mm. broad; berry reddish-purple, 6–10-seeded.

Type: Cordillera de Tacna, Peru, *Meyen* (Berlin).

Distribution: Cordilleras of southern Peru and northern Chile, possibly extending from Copiapo, Chile, to Yura, Peru.

Material seen:

Chile: Copiapo, coll. of 1876, *Meyen* (KEW).

Peru: Yura, Aug. 10, 1901, alt. 8400 ft., *Williams 2554*, type collection *L. divaricatum* (NY type, US); Cord. Tacna, coll. of 1876, alt. 2000 m., *Meyen* (G—photograph of type collection at Berlin); Dept. of Cuzco, Oct. 1839–Feb. 1840, *Gay* (MBG—photograph of type *L. leiostemum* at Paris); Cordillera de Palca, Dept. of Tacna, coll. of 1854, *Weddell* (MBG—photograph of type *L. oreophilum* at Paris).

The Meyen plant from Copiapo, Chile, is so like the photograph of the type collection at Berlin, even to the most minute detail, that the writer is inclined to suspect that they may be the same collection, the labels having been confused; especially does this possibility seem plausible since there are no other collections from within several hundred miles of Copiapo.

There are only a few leaves remaining on the type collection of *L. distichum* but they are identical with those leaves borne at the base of the branchlets in Williams' specimen, the type of *L. divaricatum*. Although there are fewer spines on Meyen's plant, some of the branchlets of *L. divaricatum* are also almost unarmed; the flowers in the two plants are identical, likewise the pubescence, the calyx-lobes, the size, shape, and lobing of the corolla, and

stamen and stigma length are in perfect agreement. As further evidence that the two plants are conspecific, it may be mentioned that the two types were collected but a few miles apart.

It seems certain that *L. oreophilum* should be placed here, the only real point of dissimilarity being that Weddell's species is described as four-merous, a character which does not have much significance in most species of *Lycium*. The type was collected in the same region as Meyen's type, and judging from the excellent photograph of Weddell's plant it is identical with *L. distichum*. *Lycium leiostemum* is referred here with some doubt, the photograph of the type being very similar to Meyen's plant in flower character, but the leaves are narrower, and if the filaments of Gay's plant (type of *L. leiostemum*) are really glabrate as the description says, it is probably a mistake to consider it as conspecific with *L. distichum*.

Lycium distichum is much like *L. fragosum*, differing mainly in that the leaves are somewhat larger, the corolla pubescent exteriorly, and stamens and style are longer. If the specimen of *L. distichum* at Kew really came from Copiapo, Chile, the two species would have almost identical ranges, a condition which would help to confirm the suspicion that they are probably the same species; however, if "Copiapo" is the wrong locality, *L. distichum* would appear to have a distinctive distribution, a fact which, coupled with the corolla and leaf characters, would provide sufficient basis for maintaining the two species.

Miers' statement concerning the generic status of *L. distichum*[56] was undoubtedly biased by his belief that the plant was a member of the *Bignoniaceae;* it is certain, however, that he had not seen the plant, as his remark "long simple distichous patent branches, terminating in a spine, indicate an opposition, not an alternation of its axils and leaves," is in direct contradiction to the note made by Meyen on the type collection which says "ramis spinosis alternis." The list of characters which Miers cited to show that the plant could not be a *Lycium*, namely, minute, non-fasciculate leaves, solitary, blue flowers, large funnel-shaped limb and small segments with included stamens, are all to be found in this genus. The leaves are neither minute nor non-fasciculate; however,

[56] Miers, Ann. & Mag. Nat. Hist. II, **14**: 345. 1854.

most of them have been shaken off, and consequently there are not many of the nodes which still have more than one leaf.

26. **L. fragosum** Miers, Ann. & Mag. Nat. Hist. II, **14**: 132. 1854, and Ill. S. Amer. Pl. **2**: 108, *pl. 67D*. 1857.

Pl. 16, figs. 10–12.

L. fagosum Mueller in Walp. Ann. Bot. **5**: 579. 1858.

L. salsum α normale var. *fagosum* Terrac. Malpighia **4**: 530. 1891 (should be *fragosum* (Miers) Terrac.).

L. deserti Philippi, Fl. Atac. 43. 1860; Reiche, Anal. Univ. Chil. **123**: 396. 1908, and Fl. Chil. **5**: 316. 1910; I. M. Johnst. Contr. Gray Herb. **85**: 112. 1929.

L. chilense α normale var. *deserticum* Terrac. *l. c.* 528, in part, as to *L. deserti* Phil.

L. breanum Philippi, Anal. Univ. Chil. **91**: 23. 1895.

An open, spreading, sparingly pubescent shrub 1–2 m. tall; branches rather slender, straight, gray, armed with thick, sharp spines; leaves linear to spatulate, 2–15 mm. long, 0.5–1.25 mm. broad, densely short hirtellous-pubescent, cinereous, borne in fascicles of 3–8, somewhat fleshy, margins frequently revolute; flowers numerous, borne singly, very commonly pendulous, pedicels 3–7 mm. long, sparingly pubescent; calyx cup-shaped, 2.5–3.5 mm. long, tube with much same pubescence as the leaves, the 4 lobes nearly as long as the tube, acute, ciliate; corolla narrowly obconic-tubular, tubular portion 11–12 mm. long, 2.5–3 mm. in diameter at summit, glabrous externally, lobes 4, oval, 1–1.5 mm. long, spreading, ciliate; stamens included or partially exserted, filaments equal or somewhat subequal, 1.5–2 mm. shorter than corolla-tube, adnate ⅓–½ the length of the corolla-tube, or slightly less, pilose the first 2–3 mm. of their free portion, corolla-tube also slightly pubescent adjacent to and below the free portion of the filaments, anthers 1–1.5 mm. long; style 1–2 mm. shorter than stamens; berry not seen, but young ovary several-ovuled.

Type: Peru, *Cuming 948* (British Museum), according to Miers' citation, but the cotype in the Kew Herbarium bears the following legend: "Cobija, Iquiqui et Arica, Peruviae meridionalis in 1831"—all three localities now within the boundaries of Chile.

Distribution: northern Chile, from Copiapo and the desert of Atacama to Arica.

Material seen:

CHILE: locality uncertain, "summit of Marañon," *Warscewicz* (KEW); Nord-Chile, *Pearce* (V); Totoral, Prov. Atacama, Dept. Copiapo, Nov. 1924, alt. 30 m., *Werdermann 472* (G, MBG, ST); vicinity of Aguada de Miguel Diaz, Prov. Antofagasta, Dept. Taltal, ca. 24° 35′ S, Dec. 1–4, 1925, *Johnston 5382* (G); Desert of Atacama, Chile, coll. of 1885–87, *Geisse 40* (NY); Cobija, Iquiqui et Arica, coll. of 1831, *Cuming 948*, TYPE collection (KEW); Des. Atacama, *Philippi* (V).

Lycium deserti is placed here because of the similarity of Philippi's description to that of *L. fragosum* and because Johnston's plant from Taltal is said by the collector to be a good match for Philippi's plant. This collection is in fruiting condition, and it is therefore difficult to compare it with Miers' type collection, but there are no points of dissimilarity between them, except that the Taltal plant has larger leaves; however, Johnston has noted on the label that the leaves are larger on his plant than on that of Philippi's. *Lycium breanum* is placed here with some hesitancy, although the original description would indicate that it is conspecific with Miers' species.

Lycium fragosum differs from *L. implexum* in having shorter stamens and style, ciliate corolla-lobes, and longer calyx-lobes; from *L. distichum* it differs in that the stamens and style are shorter, and the corolla-tube is glabrous exteriorly; there is, however, the possibility that the two species are not specifically distinct.

27. L. Gilliesianum Miers, Ann. & Mag. Nat. Hist. II, **14**: 344. 1854, and Ill. S. Amer. Pl. **2**: 137, *pl. 74B*. 1857.

Pl. 16, figs. 21–23.

L. floribundum β infaustum var. *Gilliesianum* Terrac. Malpighia **4**: 531. 1891.

L. rigidum Gill. ex Miers, Ann. & Mag. Nat. Hist. II, **14**: 344. 1854, and Ill. S. Amer. Pl. **2**: 137, *pl. 74B*. 1857, not *L. rigidum* Thunb.

L. longiflorum Philippi, Anal. Univ. Chil. V, **21**[2]: 403. 1862, and Linnaea **33**: 206. 1864.

L. patagonicum β longiflorum (Phil.) Terrac. *l. c.* 533.

L. elongatum Miers var. *longiflorum* (Phil.) Haum.-Merck, Anal. Mus. Nac. Buenos Aires **24**: 416. 1913.

L. Wilkesii Ball, Jour. Linn. Soc. Bot. **21**: 228. 1884.

L. acanthocladium Speg. Rev. Fac. Agr. y Vet. la Plata (Pl. Patag. Austr.) **3**: 552. 1897.

A very leafy, somewhat branched, sparingly pubescent shrub 1–2 m. tall; branches slender, but not flexuous, very crooked, silvery-gray, spines thick; leaves 3–7 in a fascicle, linear-spatulate to narrowly oblanceolate, 8–20 mm. long, 1–3 mm. broad, somewhat fleshy, glabrous, except for a few cilia on margins, base long-attenuate; flowers 1–3 in the nodes, pedicels 2–5 mm. long; calyx small, cup-shaped, very sparingly pubescent, 2–2.5 mm. long, irregularly 4-lobed, the lobes ½ as long or as long as tube, ciliate; corolla very narrowly tubular-obconic, tube 13–17 mm. long, 2–2.5 mm. in diameter at the summit, about 1 mm. in diameter above the ovary, glabrous externally, lobes 4, rounded, 1.5 mm. long or less, recurved, their margins sparsely, if at all, ciliate; stamens 4, equal to tube, or very slightly exserted, filaments equal or subequal, adnate to slightly above the center of the tube, pilose at base of the free portion for about 1 mm., corolla-tube pubescent for nearly 5 mm. below this region, anthers slightly more than 1 mm. long; style 16–19 mm. long, thus exserted 2–4 mm.; berry ovoid, 4–7 mm. long, about ½ as thick, 5–10-seeded, basal disc very evident.

Type: Copuncoa, Mendoza, Argentina, *Gillies* (British Museum).

Distribution: central Argentina, from Terr. Rio Negro to Prov. Mendoza.

Material seen:

ARGENTINA: Chubut, Jan. 1904, *Illin* (MBG); entre el Jaguel y las Cortaderas, Cordillera de la Rioja, Feb. 21, 1879, *Hieronymus & Niederlein 269* (D); vicinity of General Roca, Terr. Rio Negro, Sept. 1914–Feb. 1915, alt. 250–360 m., *Fischer 112* (F, G, KEW, MBG, NY, US); Patagonia, coll. of 1850, *d'Orbigny 183* (D); General Roca, Gobernacion del Rio Negro, Nov. 23, 1920, *Wetmore 792* (US); Terr. Santa Cruz, Deseado, 1899–1900, *Ameghino 26* (BA, identified as *L. acanthocladium* by Spegazzini); Naposte Grande, Sierras Pampeanus, Prov. Buenos Aires?, Feb.–Apr. 1881,

Lorentz (US), and from same locality, *Lorentz 154* (US); Sierras Pampeanus, *Lorentz* (V); Copuncoa, Prov. Mendoza, *Gillies* (KEW TYPE collection); Carmensa, Prov. Mendoza, May 11, 1928, *Parodi 8577* (G); Mendoza, Tupangato, Jan. 6, 1917, *Ruiz* (MBG); Mendoza, coll. of 1868–69, *Philippi*, photograph of supposedly authentic material of *L. longiflorum* at Berlin (G, MBG); Mendoza, *Philippi* (V, probably same collection as preceding); Terr. Santa Cruz, Oct. 6, 1929, alt. 400 m., *Donat 176* (MBG); Buenos Aires, Tartido Carmen de Patagones, Feb. 1912, *Hauman* (MBG).

Although the type collection of *L. Gilliesianum* (*L. rigidum*) is without flowers, it is certain that it is the same species which Philippi later called *L. longiflorum;* the habit, leaves, calyx, and fruit of the two are identical, and the two types were both collected at Mendoza. *Lycium Wilkesii* may be placed here with reasonable certainty, as the original description fits that of *L. longiflorum* well. *Lycium Gilliesianum* has a shorter calyx-tube, shorter calyx-teeth, and a much longer corolla and stigma than does *L. elongatum*, with which it is perhaps most easily confused.

Lycium acanthocladium does not differ from *L. Gilliesianum* in any important character, judging from the description; because of this fact, and because the plant from Museo Nacional de Buenos Aires was identified by Spegazzini as *L. acanthocladium*, the writer believes Spegazzini's species can be unquestionably reduced to synonymy.

27a. L. Gilliesianum Miers var. **longitubum** (Dammer) C. L. Hitchcock, comb. nov.

L. longitubum U. Dammer in Engl. Bot. Jahrb. **37**: 169. 1905.

Branches exceedingly thick; leaves pale green, thickly short-pubescent; calyx-lobes equal to the tube; corolla-tube slightly pubescent exteriorly, lobes 1.5–2 mm. long; stamens exserted 1 mm.

Type: Tambo in Quebrada del Toro, Prov. Salta, Argentina, Nov. 20, 1901, *Höfsten 833* (ST).

Known only from the type collection, the plant from Stockholm being the only one seen. The variety is well marked, as the above diagnosis shows, yet the plant is so definitely and closely

related to *L. Gilliesianum* that it can be accorded no more than varietal rank.

28. **L. fuscum** Miers, Ann. & Mag. Nat. Hist. II, **14**: 137. 1854, and Ill. S. Amer. Pl. **2**: 113, *pl. 68B.* 1857; Griseb. Abhandl. König. Ges. Wiss. Gött. **19**: 217. 1874. (Pl. Lorent. 169. 1874). Pl. 17, figs. 1–3.

L. penduliflorum I. M. Johnst. Physis **9**: 318. 1929.

An erect, heavy, spiny, glabrous shrub 0.3–1.5 m. tall; branches exceedingly thick and rigid, gnarled, rough, gray-brown, armed with many pungent, thick, heavy branchlets, these usually with leaves at base; leaves oblong to obovate, glabrous, blades 5–10 mm. long, 4–6 mm. broad, rounded or obtuse at apex, rounded-attenuate at base, forming a petiole 2–5 mm. long; flowers borne singly on pedicels 3–4 (6) mm. long, pendent; calyx cup-shaped, only about 1.5 mm. long, and as wide, 4–5-lobed, the lobes nearly as long as the tube in some cases, acute, margins minutely ciliate, rest of calyx glabrous; corolla very narrowly obconic, tube yellowish-green, 15–18 mm. long, 2–2.5 mm. in diameter at top, less than 1 mm. in diameter just above ovary, glabrous, except the margins of the 4 lobes, these rounded, 1–1.5 mm. long, reflexed, ciliate; stamens 4, only partially exserted, filaments subequal, about equal to corolla-tube, adnate to about $^3/_5$ the way from base of corolla-tube, pilose for nearly 2 mm. above adnate portion, adjacent corolla-tube pilose for 3 mm. below, anthers 1.5 mm. long, style about equalling stamens or slightly longer; ovary several-ovuled, but mature fruit not seen.

Type: ad San Pedro de Uspallata, in Andibus Provinciae Mendozae, Argentina, *Miers* (British Museum).

Distribution: northwestern Argentina, from Uspallata northward to northern San Juan.

Material seen:

ARGENTINA: Quebrada Ortiza, eastern part of Cordillera de Ortega, about lat. 29° 12′–21′ S, long. 69° 38′–48′ W, Jan. 14, 1926. alt. 3300 m., *Johnston 6172* (G); vicinity of Baños San Crispin, about lat. 29° 11′ S, long. 69° 44′ W, Jan. 11, 1926, alt. 3300 m., *Johnston 6120* (G TYPE of *L. penduliflorum*).

Lycium fuscum has the longest and slenderest corolla of any of

the New World species. It is closely related to *L. Gilliesianum* but differs from that species by the longer corolla, shorter style, ciliate corolla-lobes, pendent flowers, and obovate or oblong leaves. Although the type of *L. fuscum* has not been seen, the identity of this material is reasonably certain. Miers' plate and description were drawn from a specimen which consisted of but a few leaves and flowers, and his plate, as usual, cannot be relied upon too implicitly, since the flower drawn to natural size, and the one enlarged, are entirely different in shape. Those characters which are of unusual significance are the size and the shape of the leaves, the size and shape of the calyx, the length of the four fimbriate-margined lobes of the corolla, and the extent of adnation of the filaments. The nature of the leaves, in particular, is unusual, and, combined with the other common characters in the two plants, makes it seem fairly certain that Miers' and Johnston's species are the same. The types were collected in adjacent areas, which, according to Dr. Johnston, constitute a natural and to-be-expected range. The chief discrepancy between the two species is the shorter corolla in Miers' plant, but the disagreement of his figures indicates the possibility that there was some confusion of data.

29. L. Andersonii Gray, Proc. Amer. Acad. **7**: 388. 1868; Bot. Calif. **1**: 543. 1876, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 239. 1886; Rydb. Fl. Rocky Mts. 758. 1917; David. & Moxl. Fl. S. Calif. 321. 1923; I. M. Johnst. Proc. Calif. Acad. Sci. IV, **12**: 1155. 1924; Tidestrom, Contr. U. S. Nat. Herb. (Fl. Utah & Nev.) **25**: 471. 1925; Jepson, Man. Fl. Pl. Calif. 890. 1925.

Pl. 18, figs. 8–10.

L. Andersonii var. *pubescens* Wats. Proc. Amer. Acad. **24**: 65. 1889.

L. cedrosense Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1288. 1924, as to *L. Andersonii pubescens*.

L. Parishii Jepson, Man. Fl. Pl. Calif. 891. 1925, as concerns the Elsinore plants.

L. Berlandieri γ *longiflorum* var. *Andersonii* Terrac. Malpighia **4**: 521. 1891.

A profusely branched, rounded, spiny shrub 0.5–3 m. tall,

glabrous or sometimes scurfy, rarely pubescent; young branchlets somewhat flexuous, silvery-white to tan, armed with numerous spines 5–20 mm. long, older branches often unarmed and with silvery-tan to dark brown bark; leaves linear-terete, ovoid or spatuloid, succulent, apex rounded to acute, somewhat attenuate at base, 3–15 mm. long, 1–2 (3) mm. broad, somewhat scurfy to subglabrous; flowers with pedicels 3–9 mm. long; calyx cup-shaped, 1.5–3 mm. long, usually 4–5-toothed, sometimes 2-lipped, teeth about ¼ length of tube, glabrous to sparsely pubescent, margins of lobes sparingly ciliate; corolla tubular, gradually widening upward, tube 7–14 mm. long, 1–1.5 mm. in diameter at base, 2–3 mm. in diameter at top, dirty lavender, lobes 5, frequently 4, ovate in outline, 1.5–2.5 mm. long, finely ciliate, fimbriate, or simply entire, lavender or purple, fading to white, spreading; stamens about equalling corolla-tube or more commonly exserted 2–3 mm., filaments adnate about ⅓ the length of the corolla-tube, base with few scattered hairs above the point of adnation, glabrous or with few hairs below this region, anthers 1–1.5 mm. long; style about equalling corolla or exserted as much as 2–3 mm.; berry ovoid or ellipsoid, often somewhat attenuate, 3–8 mm. long, about ⅗ as thick, red, seeds light-brown, about 2 mm. long, very numerous.

Type: southeastern Nevada, coll. of 1866, *Anderson 151* (G).

Distribution: from coastal southern California to western New Mexico, northward to central Utah, and southward to Baja California and Sonora, Mexico.

Material seen:

United States of America

Without definite locality: U. S. Pacific Slope, *Lemmon* (C); coll. of 1881, *Parry 216½* (MBG); coll. of 1874, *Parry 204* (MBG).

New Mexico: 1 mi. S of Tularosa, Otero Co., June 15, 1930, alt. 1300 m., *Goodman & Hitchcock 1137* (MBG); 8 miles e. of Deming, Sept. 1, 1908, *Goldman 1459* (US); Playas Valley (La Cienega), Aug. 21, 1908, *Goldman 1444* (US).

Arizona: without locality, coll. of 1881, *Parry* (MBG); Tinajas Altas, Nov. 20, 1913, *Goldman 2315* (US); dry benches, Big Sandy River, near Owens, Sept. 20, 1917, alt. 600 m., *Goldman 2958* (US); wash between Rice and Globe, Gila Co., June 6, 1918,

Ferris 1305 (S); Santa Rita Forest Reserve, Santa Cruz Co., Sept. 20–Oct. 4, 1902, *Griffiths & Thornber 20* (US); Tucson, Pima Co., Sept. 2, 1867, *Dr. Smart* (MBG); Sabino Canyon, Sta. Catalina Mts., Jan. 6, 1920, *Bartram 235* (PA); north slope of Santa Rita Mts., Pima Co., Sept. 29, 1904, *Griffiths 6955* (MBG); Laosa to Lovare via Baboquivari, March 13–Apr. 23, 1903, *Griffiths 3623* (US); foot of Salt River Mts., Maricopa Co., March 14, 1930, *Peebles 6445* (US); opposite Double Buttes, Casa Grande-Gila Bend Rd., Feb. 23, 1931, *Peebles & Loomis 7500, 7501, 7502* (P, SAC); Phoenix, Maricopa Co., Apr. 18, 1917, *Eastwood 6172* (CA); Phoenix, May 6, 1903, alt. 300 m., *Jones* (P); Bowie, Cochise Co., Sept. 18, 1884, *Jones 4276* (CA, C, D, F, NY, P, US); Camp Bowie, Aug. 1874, alt. 1700 m., *Rothrock 448* (F, US); rocky washes, near Cameron, Coconino Co., June 8, 1922, alt. 1600 m., *Hanson A129* (MBG); bank, N. of Colorado River at Lee's Ferry, Coconino Co., Aug. 27, 1909, *Nelson 71* (US); Hermit Creek, Grand Canyon, Apr. 10, 1917, *Eastwood 6015* (CA); Ft. Mojave on the Colo. R., Apr. 1894, *Lemmon* (C); Williams' Fork of the Colorado R., March 11, 1876, *Palmer 421* (C, F, G, MBG, NY, PA, US); Peach Springs, Mohave Co., Apr. 1893, *Wilson* (C); near Oatman, Mohave Co., March 23, 1931, *Harrison, Kearney & Fulton 7579* (SAC); Oatman-Kingman Rd., Mohave Co., March 23, 1931, *Harrison, Kearney & Fulton 7611* (SAC); Big Sandy River, 45 miles s. of Kingman, Mohave Co., March 24, 1931, *Harrison, Kearney & Fulton 7625, 7626, 7627* (SAC, P); Franconia, Mohave Co., Apr. 17, 1903, alt. 300 m., *Jones* (P, S); Kofa Mts., near Quartzite, Yuma Co., Dec. 29, 1929, *Hilend 370* (UCLA); 30 miles E. of Parker, Yuma Co., March 21, 1931, *Harrison, Kearney & Fulton 7526* (SAC, P); Parker Ferry, Yuma Co., March 22, 1931, *Harrison, Kearney & Fulton 7527* (P, SAC); near northern base of Harqua Hala Mts., Yuma Co., March 21, 1931, *Harrison, Kearney & Fulton 7523* and *7524* (SAC); Yucca, March 12, 1912, *Wooton* (US); Yucca, May 17, 1884, *Jones* (P, S); north of Yuma, Apr. 26, 1906, *Jones* (P).

Utah: without locality, coll. of 1872, *Wheeler* (NY); Leavington, May 8, 1911, alt. 1600 m., *Jones* (P); Santa Clara Valley, Apr. 30, 1894, *Jones 5139* (P, US); Diamond Valley, Apr. 27, 1894, alt. 1400 m., *Jones 5125p* (P, US); Salt Lake, June, 1869,

alt. 1400 m., *Watson 942* (G, NY, US); Stansbury Is., June, 1883, *Jones* (P); Bird (Hat) Island, Great Salt Lake, June 11, 1916, *Garrett* (NY, GAR); St. George, coll. of 1877, *Palmer 365* (G); rocky hills, near St. George, Apr. 1874, *Parry 201* (D, F, G, MBG, NY, PA); St. George, Apr. 2, 1880, alt. 600 m., *Jones 1624* (C, CA, NY, P, US), the plant in the Field Herbarium under this number is *L. Torreyi;* Beaverdam Mts., May 11, 1891, *Bailey 1950* (US); Beaverdam Wash, March 18, 1905, *Goodding 2147* (C, G, MBG, NY).

NEVADA: without locality, coll. of 1872, *Wheeler* (US); southeastern Nevada in 1866, *Anderson 151* (C, G TYPE, NY); Good Springs, Apr. 30, 1905, *Jones* (P); Mica Spring, Apr. 14, 1894, alt. 1300 m., *Jones 5064as* (P, US); Candelaria, Esmeralda Co., May 14, 1882, *Shockley 205* (C, G); open sand, Candelaria, May 14, 1882, *Shockley 219* (US); Rhyolite, Nye Co., Apr. 11, 1907, alt. 1200 m., *Jones* (P); Rhyolite, Apr. 25, 1907, alt. 1300 m., *Jones* (P); mesa, Alamo, Lincoln Co., May 18, 1919, *Tidestrom 9559* (US); Erie, Clark Co., Apr. 8, 1919, alt. 935 m., *Tidestrom 8864* (US); Las Vegas, May 5, 1905, *Goodding 2305* (G, MBG).

CALIFORNIA: western Arizona or southeastern California, coll. of 1876, *Palmer* (G); desert, near Agua Caliente (Palm Springs), Jan. 10, 1880, *Parish 11* (G); Agua Caliente, March 10, 1881, *Parish & Parish 730* (G); Vallecitos, Colo. Desert, Apr. 10, 1896, *T. S. Brandegee* (NY, PA, C in part, but not F); edge of sandy wash, vicinity of Corn Springs, Chuckwalla Mts., Colorado Desert, in Lower Sonoran, Apr. 9–12, 1922, alt. 400 m., *Munz & Keck 4849* (P) and *4850* (C, P); Jurupa Mts., extreme w. end, rocky exposed situations on s. slopes, May 8, 1920, *Johnston 2272* (P, US); San Felipe, Imperial Co., May, 1899, *K. Brandegee* (C, P); Colorado River Basin, 5 mi. n. of Laguna Dam, Apr. 19, 1930, *Hilend* (UCLA); Mountain Spring, Imperial or San Diego Co., Feb. 28, 1924, *Jones* (P); desert sand, Mt. Springs, 15 miles from Mexican border, Imperial Co., May 5, 1918, alt. 700 m., *Spencer 798* (G, NY, P); Mono Lake, Mono Co., May 1922, *E. Wright* (CA); gravelly slope, Ryan to Shoshone, Inyo Co., Apr. 4, 1929, *Hoffmann* (SBM); Townsend Grade, Inyo Co., Apr. 26, 1930, *Hoffmann* (SBM); sandy soil, 5 mi. e. of Bradbury Well, Black Mts., Inyo Co., Apr. 2, 1928, *J. T. Howell 3657* (CA); rocky wall,

Wild Rose Canyon, Inyo Co., April 2, 1929, *Hoffmann* (SBM); Silver Canyon in the White Mts., E. of Laws, Inyo Co., May 9, 1906, *Heller* (MBG); Death Valley, March 12, 1924, *Jones* (P); Funeral Mts., Death Valley, Apr. 10, 1907, *Jones* (P); Darwin Mesa, Inyo Co., May 23, 1891, alt. 1550 m., *Coville & Funston 879* (US); Darwin, Apr. 27, 1897, alt. 1500 m., *Jones* (P, US); 6 miles from Darwin on Owen's Valley Road, June 11, 1930, *Ferris 7904* (C); rocky alluvial slope, E. slope of Walker Pass, Kern Co., May 13, 1930, alt. 1300 m., *J. T. Howell 4998* (CA); Red Rock Canyon, Kern Co., May 1, 1927, *Abrams 11882* (P); Mojave, May 20, 1903, alt. 1000 m., *Jones* (P); Randsburg, Kern Co., Apr. 14, 1905, *Heller 7704* (D, F, G, MBG, NY, PA, US); Randsburg to Mohave, Apr. 27, 1929, *Hoffmann* (SBM); Randsburg, Apr. 1905, *Drake* (C); 8 miles northwest of Hesperia, May 17, 1920, *Johnston* (P); Hesperia, San Bernardino Co., Apr. 15, 1892, *Trelease* (MBG); in desert sand, Barstow, Mohave Desert, Apr. 4, 1920, alt. 700 m., *Spencer 1564* (P); "ad flumen Mohave proximus, prope Barstow, San Bernardino Co.," May 2, 1922, alt. 1000 m., *Spencer 2047* (G, PA); dry rocky hill, Barstow, Apr. 13, 1919, *Munz 2606* (P); Red Rock, Barstow, Apr. 5, 1929, *Hoffmann* (SBM); Barstow, March 16, 1916, alt. 700 m., *Jepson 6612* (G); north of and near Victorville, May 11, 1926, *Jones* (P); Victorville, March 13, 1927, *Hart* (CA); in desert sand, near Victorville, Apr. 19, 1918, alt. 600 m., *Spencer 796* (G, NY, P); Victorville, Apr. 10, 1922, *Mrs. Jos. Clemens* (CA); sandy soil, halfway between Victorville and Hesperia, Mohave Desert, June 12, 1927, alt. 900 m., *J. T. Howell 2528* (CA); Mohave R., southeastern California, May 1876, *Palmer 426* (C, CA, F, G, MBG, NY, US); borders of the Mohave Desert, San Bernardino Co., May 31, 1892, *Parish 2437* (F); Morongo, Apr. 1882, *Parish & Parish 11A* (G); Warren's Well, San Bernardino Co., May 16, 1909, *T. S. Brandegee* (C); Colorado River, opposite the Needles, March 3, 1910, *J. Grinnell* (C); Rock Spring, S. E. California, coll. of 1876, *Palmer 418* (C, F, G, US); rocky slopes, Argus Mts., Apr.–Sept. 1897, *Purpus 5427* (C, G, MBG, US); Kelso, May 2, 1906, *Jones* (P); Barnwell, May, 1911, *K. Brandegee* (C); rocky desert hills, vicinity of Bonanza King Mine, east slope of Providence Mts., Mohave Desert, May 21–24, 1920, alt. 800 m., *Munz, Johnston*

& Harwood 4026a (P); stony hills, Garlic Spring, Apr. 25, 1930, *Hoffmann* (SBM); granite rocks, dry lake bed, east of Muroc, San Bernardino Co., June 13, 1921, *Ferris & Duncan 2209* (CA); Colton, coll. of 1881, *Vasey* (F, G, US); Cabezone (Cabazon, Riverside Co.?), Oct. 24, 1907, *Bailey* (US); Cabazon, March 1880, *Parish & Parish 11* (F, US); Cañon de Los Negros, Apr. 1881, *Parish & Parish 11* (PA); Lower Coahuila Creek, Riverside Co., March 29, 1898, alt. 600 m., *Leiberg 3184* (US); sandy wash, south base of Eagle Mts., Riverside Co., Apr. 9, 1922, alt. 600 m., *Munz & Keck 4811* (C, P); Palm Springs, March 6, 1922, *Mrs. R. W. Campbell 35* (CA); dry slopes, Aguanga, Riverside Co., Apr. 29, 1922, alt. 700 m., *Munz 5115* (C, P); dry canyon wall, Lower Sonoran, Andreas Canyon, March 12, 1922, *Munz 4710* (P); Whitewater, March 11, 1903, alt. 300 m., *Jones* (P); Banning, coll. of 1904, *Gilman 29* (C); Terquisquita Canyon, Riverside City, coll. F. M. Reed, Dec. 1917, *Parish 11655* (C); Elsinore, Apr. 4, 1904, *Baker 4145* (C, CA, D, F, G, MBG, NY, S, US); Acton, Los Angeles Co., June 1902, *Elmer 3757* (D, G, MBG, NY, P, S, US); open desert, Palmdale, June 14, 1927, *Hoffmann* (SBM); desert flat, Roosevelt, Apr. 27, 1929, *Hoffmann* (SBM); dry plains, Antelope Valley, Apr. 6–8, 1917, *Shaw, Spalding & Walton* (P); Santa Monica, March, 1881, *Parry 216* (MBG); Santa Monica, March, 1881, *Parry 314* (US); Borrego Spring, San Diego Co., Apr. 19, 1906, *Jones* (P); near County Poor Farm, Mission Hills, San Diego, May 12, 1903, *Abrams 3464* (F, G, MBG, NY, P); San Diego, March 9, 1882, *Jones 3045* (US only); sandy soil, Aguanga, in the arid hills of interior San Diego Co., Nov. 27, 1927, *J. T. Howell 3274* (CA); Jacumba, Apr. 1905, *T. S. Brandegee* (C, US); Jacumba Springs, Apr. 11–16, 1924, *Eggleston 19809* (P); Chollas Valley, March 15, 1883, *Orcutt* (C, F); 3 miles east of Warren's Well, May 6, 1922, *Munz & Johnston 5200a* (P).

MEXICO

BAJA CALIFORNIA: without locality, coll. of 1883, *Orcutt* (G); coll. of 1882, *Parry* (MBG); Ensenada, Apr. 12, 1882, *Jones* (F), approaches the f. *deserticola;* San Felipe, sandy wash, Feb. 6, 1929, *Hoffmann* (SBM); San Felipe, May 1899, *T. S. Brandegee* (C); 15 miles south of San Diego, California, Apr. 5, 1882, *Jones* (G); dry Tia Juana River bank, July 28, 1912, *Smith 5212* (F);

hills at Tia Juana, May 14, 1903, *Abrams 3491* (NY, P); Tia Juana, May 28, 1883, *Orcutt* (C); northern Lower California, *Parry & Pringle* (G); Comondu, March 22, 1889, *T. S. Brandegee* (C), plant densely pubescent; San Antonio, June 3, 1893, *T. S. Brandegee* (C); Magdalene Is., Jan. 22, 1889, *T. S. Brandegee* (C); San Martin Is., March 13, 1897, *T. S. Brandegee* (C); La Paz, June 14, 1897, *Rose 1314* (US); La Paz, Jan. 20–Feb. 5, 1890, *Palmer 101* (F, G, NY, US), branches slender and flexuous; stony ravines, Los Angeles Bay, Gulf of California, Dec. 1887, *Palmer 559*, TYPE collection *L. Andersonii* var. *pubescens* (G TYPE, NY, US).

SONORA: Altar to Sasabe, Sept. 21–23, 1904, *Griffiths 6921* (MBG).

SINALOA: vicinity of Fuerte, March 26, 1910, *Rose, Standley & Russell 13555* (NY, US); La Constancia, coll. of 1924, *Ortega 5520* (PA, US).

The following numbers approach the forma *deserticola:*—near Wittman, Arizona, March 30, 1930, *Peebles & Loomis 6727* (US); on California side of Colorado River, near Parker Ferry, March 22, 1931, *Harrison, Kearney & Fulton 7529* (SAC); Elsinore, Riverside Co., California, *Johnston 2028* (C, G, P); San Diego, California, coll. of March, 1882, *Jones* (CA, MBG, NY, P).

These numbers are intermediate between *L. Andersonii* and *L. Andersonii* var. *Wrightii:*—on flats, near Magma, Pinal Co., Arizona, Feb. 28, 1930, *Peebles & Harrison 6431* (MBG, SAC, P); "Saar de Cienega towards Chiricahui," Sept. 2, 1851, *C. Wright 1610*, in part (G).

Because of the fact that *L. Andersonii* has such an extended range, it is not surprising that it breaks up into several local, geographically isolated entities. The leaves are typically linear-spatulate and terete, glabrous, and rather succulent, but some are found that are almost obovate and more or less flattened. In some of the material from southwestern California, adjacent Arizona, and Lower California, such as the plant which Watson called *L. Andersonii* var. *pubescens*, considerable pubescence is present. Jones' collection from Franconia, Arizona, Apr. 17, 1903, is the other collection seen which is densely pubescent.

Lycium Andersonii has been most frequently confused with *L.*

Torreyi, from which it sometimes is distinguished with difficulty. The lanate condition of the corolla-lobes in the latter species is one almost infallible criterion, however. The following table sums up the differences:

L. Andersonii	*L. Torreyi*
Leaves linear-spatulate, seldom over 3 mm. broad.	Leaves elliptic to spatulate, usually over 3 mm. broad.
Corolla-lobes rounded, margins simply entire to ciliate.	Corolla-lobes obtuse to acute, margins densely white-lanate-ciliate.
Corolla-tube about 2 mm. in diameter at top	Corolla-tube usually over 2.5 mm. in diameter at top.

Several collections have been seen, such as, St. George, Utah, Apr. 2, 1880, *Jones 1624* (F); near Dome, Yuma, Arizona, March 10, 1928, *Peebles & Harrison 5045* (SAC); in desert sand, Palm Canyon, Riverside Co., California, March 27, 1918, *Spencer 797* (NY, P), which appear to be hybrids of the two species. In such cases the whole plant may be almost exactly intermediate between the two species in leaf and corolla characters, or the suspected hybrid may have a corolla shaped like *L. Andersonii* with the lanate lobes of *Torreyi*, as well as having leaves like the latter species.

29a. L. Andersonii var. **Wrightii** Gray, Bot. Calif. **1**: 543. 1876, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 239. 1886. Pl. 18, figs. 11–12.

L. Berlandieri γ *longiflorum* var. *Andersonii* subvar. *Wrightii* (Gray) Terrac. Malpighia **4**: 521. 1891.

Flowers small, 5–8 mm. long, usually 4-lobed; leaves small, elliptic-spatulate, 3–8 mm. long; stigma usually exserted 2–3 mm.

Type: probably "Saar de Cienega towards Chiricahui, Ariz." Sept. 2, 1851, *C. Wright 1610* (G).

Distribution: southern Arizona and adjacent northern Mexico.

Material seen:

United States of America

Arizona: coll. of 1869, *Palmer* (G, NY, US); Camp Grant, July 10, 1867, *Palmer 199* (G, MBG); "Saar de Cienega towards Chiricahui," coll. of 1851–52, *C. Wright 1610*, probably type col-

lection (G TYPE, MBG, NY, US); Blue River, Greenlee Co., Sept. 8, 1902, *Davidson 1013* (G); 6 miles south of Benson, June 20, 1930, *Goodman & Hitchcock 1235* (MBG); adobe soil, vicinity of Benson, March 2, 1910, *Rose, Standley & Russell 12302* (NY, US); near Sacaton, Aug. 11, 1926, Pinal Co., *Peebles & Harrison 2723* (US); Oracle to Redington, March 13–Apr. 23, 1903, *Griffiths 3751* (US); dry washes, Pinal Creek, Sept. 1, 1910, *Goodding 714* (D, G, NY, US); foothills of the Santa Catalina Mts., Pima Co., July 28, 1881, *Pringle* (G, in part only); near Kits Peak, Baboquivari Mts., Pima Co., Aug. 1, 1916, alt. 1300 m., *Lutz F4040E* (NY); Fort Lowell, Pima Co., Nov. 11, 1893, *Holzner 2649* (US); near Tucson, June, 1899, *Eby* (MBG); Tucson to Steam Pump, March 13–Apr. 23, 1903, *Griffiths 3642* (US); Tucson, Aug. 17, 1903, alt. 700 m., *Jones* (P); Santa Cruz Valley, near Tucson, July 25, 1881, *Pringle* (D, F, NY, P, PA); mesas near Tucson, Sept. 7, 1884, *Pringle* (C, D, NY, PA); Tucson, June 16, 1855, *Schott* (F); Tucson, Nov. 3, 1893, *Toumey* (US); Tucson, Nov. 3, 1894, *Toumey* (C, CA, DL, NY, US); Range Reserve near Tucson, July 11, 1911, *Wooton* (US).

MEXICO

SONORA: Pinacate, Jan. 14, 1910, *Lumholtz 29* (G).

The type of this variety is almost certainly C. Wright's number 1610, which, however, appears to consist of two different plants. One of them is *L. Andersonii*, the other is identical with the second number cited by Gray, "E. Palmer, in 1869," and is probably the plant which he had in mind when he drew up his varietal description. Gray cited this collection as "L. Berlandieri Dunal in DC." in Proc. Amer. Acad. **6**: 47. 1862, thus indicating that he was somewhat puzzled as to its true status; this is not surprising, because, due to the small four-lobed corolla, this variety resembles *L. Berlandieri* very closely. However, the corolla-tube in *L. Berlandieri* is more enlarged toward the summit, and is usually shorter in proportion to the lobes.

Collections from Tucson, Arizona, have corollas as in this variety, the leaves, however, being much larger. Such plants do not seem to merit nomenclatural rank, and since they resemble the variety *Wrightii* in corolla characters, the writer has placed them here. Collections of this nature are:

United States of America

Arizona: Casa Grande, Pinal Co., Oct. 3, 1930, *Peebles 7389* (US); in wash, Sacaton Mts., Sept. 26, 1925, *Peebles & Kearney 97* (SAC); Fresnal, Papago Indian Reservation, Pima Co., Oct. 11, 1925, *Peebles, Harrison & Kearney 404* (SAC); Catalina Mts., Aug. 19, 1903, alt. 1300 m., *Jones* (P); Santa Cruz Valley, Tucson, Sept. 24, 1903, alt. 800 m., *Thornber 33* (C, MBG, NY, P, US); mesa south of Tucson, Sept. 25, 1880, *Engelmann* (MBG); Willcox, Cochise Co., Aug. 9, 1909, *Goldman 1615* (US); dry sandy roadside, Tempe, Maricopa Co., Aug. 24, 1901, *Kearney 112* (MBG, US).

29b. L. Andersonii forma deserticola C. L. Hitchcock, nom. nov.

L. Torreyi var. *Wrightii* (Gray) Jepson, Man. Fl. Pl. Calif. 891. 1925.

Leaves 20–35 mm. long, 1–2 mm. broad, otherwise as in the species.

Type: Palm Springs (Agua Caliente), desert base of San Jacinto Mts., Riverside Co., California, April 4–13, 1896, *S. B. Parish 4132* (MBG no. 127372).

Distribution: Colorado Desert of California and adjacent Arizona.

Material seen:

United States of America

Without locality: coll. of 1876, *Parry & Lemmon 270* (G, MBG).

Arizona: Wellerich Dome, Jan. 1916, *Monnet 1098* (CA), Maricopa, May, 1885, *A. Gray* (G); near Hyder, Yuma Co., Feb. 1930, *Peebles 6426* (US).

California: near Old Dad Mt., Providence Mts., Mojave Desert, Apr. 13, 1930, *Hilend 384* (UCLA); bluffs, ranch, Arroyo Terquisquita, Riverside Co., Feb. 12, 1907, *Parish 1203* (S); Arroyo Terquisquita, Feb. 20, 1907, *F. M. Reed 1203* (C); banks of the Arroyo Terquisquita, May 5, 1926, alt. 250 m., *F. M. Reed 5289* (P); San Felipe Canyon, Colorado Desert, San Diego Co., Apr. 14, 1913, *Eastwood 2641* (CA, G, US); near Shaver's Well, Colorado Desert, Feb. 16, 1926, *Jones* (P); Palm Canyon, Riverside Co., Nov. 26, 1921, *Mrs. R. W. Campbell 12* (CA); Palm

Canyon, March 27, 1927, *Epling* (MBG); Palm Springs, Nov. 1925, *Merritt* (CA); Palm Springs (Agua Caliente), desert base of San Jacinto Mts., Apr. 4–13, 1896, alt. 200 m., *Parish 4132* (C, G, MBG TYPE, NY, US); in arenis, Palm Springs, Colorado Desert, Apr. 28, 1922, *Spencer* (MBG).

Jepson's *L. Torreyi* var. *Wrightii* is apparently a misconception of Gray's variety, as the plants which Jepson had in mind, namely, the plants of the Colorado Desert, are certainly not those of Gray's var. *Wrightii* which does not occur in California. Therefore, a new name must be given this form. There is no doubt as to the relationships of this complex; it is much more closely related to *L. Andersonii* than to *L. Torreyi*, as is evidenced by the fact that the corolla is shaped like the former and has sparsely ciliate rather than lanate-ciliate corolla-lobes; however, *L. Torreyi* does occur in the Coachella Valley.

30. L. Torreyi Gray, Proc. Amer. Acad. **6**: 47. 1862; Bot. Calif. **1**: 543. 1876, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 239. 1886; Hemsl. Biol. Cent.-Am. Bot. **2**: 426. 1882; Coult. Contr. U. S. Nat. Herb. (Bot. W. Tex.) **2**: 302. 1892; Woot. & Standl. Contr. U. S. Nat. Herb. (Fl. N. Mex.) **19**: 569. 1915; Rydb. Fl. Rocky Mts. 758. 1917; David. & Moxl. Fl. S. Calif. 321. 1923; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1288. 1924; Tidestrom, Contr. U. S. Nat. Herb. (Fl. Utah & Nev.) **25**: 471. 1925; Jepson, Man. Fl. Pl. Calif. 890. 1925. Pl. 17, figs. 19–21.

L. Torreyi var. *filiforme* Jones, Proc. Amer. Acad. II, **5**: 714. 1895.

L. Berlandieri γ *longiflorum* Terrac. Malpighia **4**: 521. 1891.

A much-branched, spreading shrub 1–3 m. tall, with heavy spines 5–10 mm. long, or practically unarmed; branches densely leafy, glabrate; leaves usually spatulate, but sometimes elliptic or oblanceolate, 1–5 cm. long, 0.3–1.0 (1.5) cm. broad, usually somewhat acute at apex, attenuate at base to a short petiole 2–3 mm. long, midnerve visible; flowers 1 or 2 (3) in a fascicle, pedicels 5–20 mm. long; calyx cup-shaped to tubular, 2.5–4.5 mm. long, about 2 mm. in diameter, sparsely pubescent to glabrate, lobes 5, ¼–½ the length of the tube, triangular, margins somewhat ciliate; corolla-tube narrowly obconic, 8–15 mm. long, somewhat

constricted at top of ovary, and flared slightly at summit, 1.5–2 mm. in diameter at base, 3–4 mm. in diameter at top, greenish-lavender or whitish, usually glabrous without, but sometimes with few scattered hairs, the 5, less commonly 4, lobes rounded to oval or even lanceolate, 1–3 times as long as broad, and ⅕–¼ the length of the tube, spreading, their margins densely ciliate-lanate with branched hairs which are apparent as a tiny white fringe; stamens equalling or slightly shorter than the lobes, thus usually exserted but slightly, filaments adnate to about the middle of the corolla-tube, rather densely hairy for about the first 1.5 mm. of their free portion, adjacent corolla-tube also hairy, anthers 1–1.5 mm. long; style slightly longer than stamens, usually exserted 2–3 mm. beyond corolla-tube; berry ovoid, 6–10 mm. long, ⅔ as thick, bright red, 8–30-seeded; fruit very juicy, sweet and not unpalatable.

Type: Fort Yuma, California, March 3, 1855, *Thomas* (G). Gray cited six collections in his original description, but did not designate any type. The above collection is very representative for the species and has the added advantage of being represented in both the New York Botanical Garden and the Gray Herbarium.

Distribution: western Texas, New Mexico, southern and western Arizona, southwestern Utah, southeastern Nevada, the Colorado and southern Mohave Deserts of California, and the states of Sonora, Chihuahua and Hidalgo, Mexico.

Material seen:

UNITED STATES OF AMERICA

WITHOUT LOCALITY: *C. Wright 1604*, on this sheet Gray has written: "these numbers (1604 and 1608) much confused; I have these as 1609 only, and no Lycium as 1608 or 1604," (NY); *Mex. Bound. Surv. 1029* (US); *Schott 158*, Mex. Bound. Surv. (F); *Fremont's Exp. Calif.* 1843–4 (NY).

TEXAS: El Paso, *C. Wright 1609* (F, G, MBG), *L. puberulum* is also under this number; Rio Grande bottom, coll. of 1881, *Havard 160* (G, PA); El Paso, Sept. 25, 1901, *Bailey 726* (US); El Paso, banks of the Rio Grande, May 8–19, 1902, *Earle 466* (NY); El Paso, Apr. 19, 1884, *Jones 3730* (C, D, F, P, US); El Paso, coll. of 1881, *Lemmon* (C); El Paso, June 17, 1893, *Mearns 1490* (S, US); vicinity of El Paso, coll. of 1911, *Stearns 131* (US);

El Paso, coll. of 1881, *Vasey* (F, G, US); El Paso, Apr. 1881, *Vasey* (US); Fabens, El Paso Co., July 3, 1921, *Ferris & Duncan 2443* (CA, NY, S); plains and low hills, El Paso, *Bigelow* (NY); Infie, near Laredo, Aug. 1899, *Mackenzie 98* (MBG); Rio Grande near Ruidoso, Oct. 1883, *Havard 89* (G, US); Croton Camp, Matada Ranch, Dickens Co., June 15, 1904, *Coville 1869* (US); alluvions of the Rio Grande, *C. Wright 301* (NY, US).

New Mexico: on the upper Rio Grande, coll. of 1851–52, *C. Wright 1608* (MBG, NY, US); New Mexico, *C. Wright 1607* (G); La Luz Canyon, La Luz, May 24, 1902, *Rehn & Viereck* (PA); valley of Rio Grande, 15 mi. west of El Paso, Texas, Dona Ana Co., July 11, 1917, *Munz 1270* (P); chaparral from El Paso to Copper Mines, Apr. 1851, *Thurber 196* (G, NY); 9 miles south of Las Cruces, June 16, 1930, alt. 1100 m., *Goodman & Hitchcock 1138* (MBG); Las Cruces, Dona Ana Co., July 20, 1889, *Munson & Hopkins* (US); irrigation ditch, 5 mi. from Las Cruces, June 30, 1918, *Ferris 1130* (S); canal bank, Vado, Aug. 13, 1930, alt. 1150 m., *Fosberg S3642* (MBG); Las Cruces, June 16, 1891, *Dewey* (US); bank of slough, 2 mi. N. of Fairacres, Dona Ana Co., July 27, 1930, alt. 1170 m., *Fosberg S3361* (MBG); 2 miles north of Mesquite, Aug. 27, 1930, alt. 1160 m., *Fosberg S3417* (MBG); Mesilla Valley, Dona Ana Co., May, 1894, alt. 1200 m., *Wooton* (NY, US); Mesilla, Mesilla Valley, May 3, 1899, *Wooton* (US); Mesilla Valley, May, 1903, *Wooton* (C, P, S); Mesilla Valley, May, 1905, *Wooton* (DL, US); Mesilla Valley, July, 1906, alt. 1200 m., *Wooton & Standley* (US); Mesilla Valley, July 21, 1907, alt. 1200 m., *Wooton & Standley 3343* (S, US); Mesilla Valley, Apr. 29, 1906, *Standley 15* (MBG); Agricultural College, Mesilla Valley, May, 1894, *Wooton* (US); Mesilla Valley, June 16, 1897, *Wooton 13* (C, D, G, MBG, NY, S, US); Mesilla, June 16, 1897, alt. 1200 m., *Wooton 13½* (C, D, MBG, NY, P, S, US); lake east of Dona Ana Mts., Sept. 6, 1908, *Wooton & Standley* (US); Organ Mts., Dona Ana Co., May 25, 1898, *Herrick 235* (US); mesa west of Organ Mts., Dona Ana Co., Oct. 25, 1904, *Wooton* (US); 8 miles north of Deming, Luna Co., Sept. 3, 1908, alt. 1400 m., *Goldman 1503* (US); 7 miles north of Las Palomas Hot Springs, Sierra Co., Oct. 28, 1909, *Goldman 1799* (US); Rio Grande, 20 miles above Rincon, Sierra Co., Sept. 6, 1904, alt. 1400 m., *Met-*

calfe 1282 (CA, D, F, G, NY, P, US); irrigation ditch, San Antonio, Socorro Co., June 21, 1921, *Ferris & Duncan 2319* (CA, MBG, NY, S); Socorro, Socorro Co., Aug. 20, 1909, *Goldman 1645* (US).

Arizona: *Wheeler*, coll. of 1871 (G); southeastern Arizona, *Lemmon* (C); Colorado River Valley, March, 1876, *Palmer* (NY, PA); Williams' Fork of Colorado River, March 11, 1876, *Palmer 424* (F, G, MBG, PA, US); Sacaton, Pinal Co., March 15, 1930, *Peebles 6446* (US); Sacaton, March 15, 1926, *Peebles & Harrison 1165* (US); Agua Caliente, March 19, 1914, *Carlson* (CA); Yuma, coll. of 1881, *Vasey* (G, US); bottom-lands near the mouth of the Gila, Yuma Co., coll. of 1855, *Schott* (F); near Dome, Yuma Co., March 10, 1928, *Peebles & Harrison 5045*, suggestive of hybrid between *L. Torreyi* and *L. Andersonii* (SAC); Beaverdam, Apr. 5, 1894, alt. 600 m., *Jones 5015*, type collection *L. Torreyi* var. *filiforme* (C, MBG, NY, P type, US); near The Needles, Mohave Co., March 14, 1905, *MacDougal 10* (NY); Fort Mojave, sandy summit of desert, coll. of 1860–61, *Cooper* (G); Fort Mojave, Feb. 25, 1861, *Cooper* (US); Hardyville, Mohave Co., May 8, 1876, *Palmer 425* (C, F, G, MBG, NY, PA, US); near Petrified Springs, Littlefield, Mohave Co., Apr. 29, 1919, *Tidestrom 9237* (NY).

Utah: southern Utah, coll. of 1874, *Parry 202* (D, F, G, MBG, PA); in fields along Santa Clara Creek, St. George, May 3, 1919, *Tidestrom 9282a* (PA); St. George, Washington Co., May 11, 1891, alt. 875 m., *Bailey 1952* (US); dry roadside, from Leeds to St. George, June 1, 1929, alt. 1100 m., *Cottam 4015* (P, GAR); St. George, March 30, 1926, alt. 1000 m., *Field Biology Class of Dixie College S. 32* (GAR), hybrid between *Torreyi* and *Andersonii ?*; St. George, Apr. 2, 1880, *Jones 1624*, hybrid between *Torreyi* and *Andersonii ?* (F), but the remainder of the plants under this number are *L. Andersonii;* St. George, coll. of 1877, *Palmer 365* (G in part, US, NY); St. George, coll. of 1877, *Palmer 366* (G, NY).

Nevada: Karshow, Apr. 26, 1902, *Goodding 633* (D, MBG); St. Joe, Apr. 9, 1894, alt. 1200 m., *Jones 5030h* (P, US); Moapa, Clark Co., May 5, 1909, *Kennedy 1816* (F, PA, US); Muddy River, near Moapa, July 5, 1924, *F. O. Ballou* (S); Muddy River,

Moapa, March 20, 1919, *Tidestrom 8618* (PA); near St. Thomas, Clark Co., May 6, 1891, *Bailey 1928* (US); Las Vegas, June, 1915, *K. Brandegee* (C); Vegas Wash, near Colorado River, Apr. 15, 1919, alt. 450 m., *Tidestrom 8981* (CA, PA); on mesa, Las Vegas, May 28, 1919, alt. 610 m., *Tidestrom 9679* (NY); flood plain at Muddy River, St. Thomas, March 21, 1919, *Tidestrom 8637* (PA); El Dorado Canyon, Lincoln Co., coll. of 1880, *T. W. Davis* (MBG).

California: Fort Yuma, Colorado Desert, March 3, 1855, *Thomas* (G, NY); Yuma, near bridge, June 29, 1925, *McMinn 1462* (S); Yuma, Feb. 20, 1881, *Parish & Parish 781* (G, S); bottomland of Colorado River, Ft. Yuma, Feb. 26, 1913, *S. B. Parish 8491* (G, S); California and Sonora near Fort Yuma, March 6, 1855, *Schott* (NY); Camp Cady, May, 1882, *Parish & Parish 781a* (S); Mason's, Colorado Desert, Apr. 9, 1896, *T. S. Brandegee* (C), possibly a hybrid between *Torreyi* and *Fremontii;* Needles, on benches of Colorado River, May 11, 1913, alt. 150 m., *Jepson 5484* (G); Colorado River bottoms, near Blythe, Riverside Co., June 19, 1918, *Ferris 1013* (CA, S); Palm Canyon, Apr. 4, 1917, alt. 300 m., *Johnston 1035* (C, P, S, US); in rocky places, Snow Creek, near Palm Springs, Riverside Co., Apr. 10, 1922, alt. 150 m., *Spencer 2095* (G, PA); Carisso Creek, Colorado Desert, March 27, 1901, *T. S. Brandegee* (C); Coyote Canyon, west borders of Colorado Desert, Apr. 1902, alt. 150 m., *Hall 2800* (C); Hawley's Station, Mohave Desert, May 1882, *Parish 781* (MBG, US); near Daggett, San Bernardino Co., Apr. 27, 1929, *Hoffmann* (SBM); bank of Mohave River, 11 mi. s. of Barstow, Apr. 14, 1932, *Munz & Hitchcock 12256* (P).

Mexico

Sonora: Libertad, March 20, 1926, *Long 32* (US).

Chihuahua: Juarez, June 26, 1891, *Evans 3397* (MBG); valley of Rio Grande, Paso del Norte, Sept. 14, 1886, *Pringle 786* (C, D, F, G, MBG, NY, PA, ST, US, V); vicinity of Paso del Norte, June 1, 1883, *Oyster* (CA).

Hidalgo: near Ixiquilpan, coll. of 1905, *Rose, Painter & Rose 8949* (US).

31. L. Parishii Gray, Proc. Amer. Acad. **20**: 305. 1885, and Syn. Fl. N. Amer. ed. 2, 2^1: 437. 1886; Abrams, Fl. Los Angeles

& Vic. 324. 1917; David. & Moxl. Fl. S. Calif. 321. 1923; Jepson, Man. Fl. Pl. Calif. 891. 1925, in part only.

Pl. 18, figs. 13–15.

L. Pringlei Gray, Proc. Amer. Acad. **20**: 305. 1885, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 437. 1886.

L. Richii Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1287. 1924, in large part, as to description and synonymy.

A rather rigid, much-branched, spiny shrub 1–3 m. tall, pubescent, somewhat glandular, armed with short, sharp spines 3–5 mm. long; branches spreading, the old epidermis silvery to dark brown; leaves spatulate, sometimes somewhat elliptic, 1–4 in a fascicle, 3–10 mm. long, 1–4 mm. broad (much larger on very young and vigorous branches), rounded to obtuse at apex, contracted to a short petiole, very pubescent, sometimes cinereous; flowers few, borne singly, pedicels 5–10 mm. long; calyx densely pubescent, campanulate, 2.5–6 mm. or more long, lobes 5, erect, oblong-oval, apex rounded to acute, ½ as long to considerably longer than tube; corolla bright purple, throat usually darker within, tube brownish, narrowly campanulate to narrowly obconic, rather conspicuously contracted above the ovary, 6–10 mm. long, 2–3 mm. in diameter at the summit, lobes 5, somewhat rotate, oval, ¼–⅓ as long as tube, their margins rather densely ciliolate; stamens about equalling corolla-lobes, exserted, due to the spreading of the latter, filaments adnate about half the length of the corolla-tube, densely pubescent on the lower fourth of the free portion, adjacent corolla-tube less hairy, anthers about 1.25 mm. long; style about equalling longer stamens; berry red, ovoid, 4–6 mm. long, 3–5 mm. thick, 7–12-seeded.

Type: mesa in the San Bernardino Valley, San Bernardino Co., California, April 1, 1881, *S. B. & W. F. Parish 795* (G). There is a note on the sheet of the type collection in the University of California Herbarium which reads: "There was but a single shrub on the mesa north of San Bernardino near what is now Arrowhead Station on the branch of the Santa Fe R. R. to Highland. It was long since destroyed. The shrubs near Elsinore reported to be of this species are not so, probably *L. californicum*, although I have not seen flowering specimens." This note was written by Mr. S. B. Parish, Aug. 1, 1918.

Distribution: known only from two stations in California, the type locality and Vallecitos in the Colorado Desert; however, it is apparently rather common in southern Arizona, probably extending across the extreme southern portion of the state into northern Sonora, Mexico.

Material seen:

United States of America

California: mesa, San Bernardino, Apr. 1, 1881, *S. B. & W. F. Parish 795* (F, G type, MBG, PA, US); mesas, San Bernardino, Apr. 1885, *S. B. Parish 795* (C, S, US); mesa north of San Bernardino, May, 1885, *S. B. Parish* (NY); Vallecitos, Colorado Desert, Apr. 10, 1896, *T. S. Brandegee* (C in part, F); Colorado Desert, Apr. 1905, *T. S. Brandegee* (C); in small canyon near Mt. Palm springs, San Diego Co., Apr. 4, 1932, *Munz & Hitchcock 12098* (P), shade plants like type of *L. Pringlei*, plants in sun with much shorter calyx-lobes.

Arizona: Bill Williams Mt., coll. of 1870, *Palmer* (US); near Mohawk, Yuma Co., March 8, 1928, *Peebles & Harrison 5007* (US); near Mohawk, Yuma Co., Apr. 5, 1931, *Peebles 7709* (P, SAC); Mohawk Pass, Apr. 12, 1930, *Peebles 6795* (US); dry rocky hill, Mohawk, Oct. 8, 1927, *Peebles, Harrison & Kearney 4920* (US); Vekol Valley, March 2, 1930, *Fulton 6436* (US); *Peebles & Loomis 7497* (P, SAC); near Aztec, Yuma Co., March 28, 1930, *Kearney & Harrison 6554* (US); between Casa Grande and Gila Bend, March 28, 1930, *Harrison & Kearney 6538* (MBG, P, US); Coyote to Santa Rosa, March 13–Apr. 23, 1903, *Griffiths 3995* (US); south of Wellton, March 28, 1930, *Harrison & Kearney 6560* (P, US).

Mexico

Sonora: washes of streams, March 28, 1884, *Pringle*, type collection *L. Pringlei* (CA, D, F, G type, NY, PA, US); Sonora, '84 (NY).

Lycium Pringlei, described from a collection made by Pringle in northwestern Sonora near the United States boundary, differs but slightly from the type of *L. Parishii*. The calyx-lobes are longer, but the flowers of the two are identical. On the sheet of the type collection of *L. Pringlei* at Field Museum, one of the two branches is almost the counterpart of the type of *L. Parishii*.

For some unknown reason *L. Parishii* has been collected but relatively a few times, a fact which would lead one to suppose that it is rather a rare plant. However, the notes made by Mr. Peebles and his associates at the United States Field Station at Sacaton, Arizona, indicate that it is fairly common in that region, ranging across the state near the Mexican boundary. It is evident from Parish's note that he thought the species was eradicated when the bush from which the type had been collected was destroyed (the Elsinore plants were *L. Andersonii*).

The long calyx-lobes furnish the most striking characteristic for this species; however, at times (usually on old branches) the calyx-lobes are shortened, rarely being scarcely more than one millimeter long. In all instances, they are equally lobed rather than irregularly cleft, as is the case in *L. Andersonii;* also, the corolla-tube tends to be more conspicuously expanded at the summit. The dense pubescence is another character which helps to separate it from *L. Andersonii.* Harrison and Kearney's number 6538 is unusual in that some of the calyx-lobes are ovate-lanceolate and over five millimeters in length, a condition which is more suggestive of the type of *L. Pringlei* than that of *L. Parishii.*

32. L. humile Philippi, Fl. Atac. 43. 1860; Reiche, Anal. Univ. Chil. **123**: 397. 1908, and Fl. Chil. **5**: 317. 1910.

Pl. 17, figs. 7–9.

L. chilense α normale var. *deserticum* Terrac. Malpighia **4**: 528. 1891, in part.

A low, prostrate or ascending, unarmed, glabrous perennial 6–20 cm. tall, spreading by underground stems, often forming dense matted growths; branches much shortened, old ones gnarled and twisted, rather densely covered with leaves, straw-colored, glabrous; leaves obovate-spatulate to linear-oblanceolate, thick and fleshy, 5–15 mm. long, 2–6 mm. broad, rounded or obtuse, gradually attenuate to a very short petiole, borne singly, or less commonly, in 2's or 3's; flowers borne singly at the nodes on pedicels 0.5–1.5 mm. long; calyx tubular, unusually large, tubular portion about 4 mm. long, 2 mm. in diameter, glabrous, lobes 5, triangular, about 1 mm. long, their margins tomentulose-ciliate;

corolla infundibuliform, tube 12–14 mm. long, about 3 mm. in diameter at the summit, little more than 1 mm. in diameter at the top of the ovary, whitish, glabrous, lobes 5, oval, about 2 mm. long, spreading, their margins not ciliate; stamens 5, partially included, filaments unequal, long ones nearly 1 mm. longer than tube of the corolla, 2 mm. or more longer than shortest one, adnate to the corolla-tube for about half its length, very sparingly pubescent at the base of the free portion, corolla somewhat pubescent for 2–3 mm. below free portion of filaments, anthers 1 mm. long; style exceeding stamens, usually exserted 2–3 mm.; berry "black, subglobose."

Type: no type specified, but "prope Cachiyuyal, 24° 22′ lat. m. 4000 p. s. m." *Philippi*, is the first collection cited (Museo Nacional, Santiago, Chile).

Distribution: dry interior valleys of Chile from the Province of Atacama to the Province of Antofagasta.

Material seen:

Chile: Salar Punta Negra, Prov. Antofagasta, Dept. Taltal, Feb. 1926, alt. 3500 m., *Werdermann 1002* (C, CA, F, G, MBG, ST); San Andres, lat. 26° 59′ S, long. 69° 39′ W, Prov. Atacama, Dept. Copiapo, Nov. 2, 1925, alt. 2200 m., *Johnston 4829* (G); Desertum Atacama, *Philippi 758* (MBG, photograph of specimen at Berlin); Agua del Profita, in des. Atacama, *Philippi* (V).

Lycium humile resembles *L. repens* in habit and the nature of the calyx, but has a longer corolla and pubescent filament bases. It differs from *L. Fremontii* in general habit and lack of pubescence on the corolla, calyx, and leaves.

33. L. repens Speg. Rev. Fac. Agr. y Vet. la Plata (Pl. Patag. Austr.) **3**: 554. 1897, and Anal. Soc. Cient. Arg. (Nov. Add. Fl. Patag.) **53**: 169. 1902. Pl. 17, figs. 4–6.

A dwarfed, unarmed, prostrate or tufted pubescent plant 5–15 (25?) cm. tall, spreading by creeping surface or underground stems; branches straw-colored to tan, rather tardily glabrous, densely pubescent on youngest parts, dark brown, thick, and corky on underground portions, 2–8 cm. long; leaves 1–3 in a fascicle, spatulate or obovate, 4–20 mm. long, 2–5 mm. broad, rounded or obtuse at the apex, attenuate to a short petiole-like

base, thick and apparently fleshy, rather densely covered with somewhat hispidulous, simple or forked hairs, often giving the plant a grayish appearance; pedicels 2–5 mm. long, pubescence same as on leaves; flowers borne singly, calyx tubular, 2.5–4 mm. long, 2.5–3 mm. in diameter, the 5 lobes about ½ the length of the tube, pubescence as on leaves; corolla "light blue," nearly tubular, slightly expanded at summit, the tube 4–6 mm. long, about 2 mm. in diameter, glabrous except for the rather conspicuous ciliate margins of the 5 lobes, these oval, about ¼ length of tube, somewhat spreading; stamens 5, included, equal in length to corolla-tube or 1–2 mm. shorter, filaments adnate nearly half the length of the tube, or slightly less, equal or subequal, filaments and corolla both glabrous, anthers about 1 mm. long; style equalling or slightly exceeding stamens, usually about equalling corolla-tube; ovary with conspicuous disc at base; berry "globose-obovate," 8 mm. long and 6 mm. in diameter, "glabrate, shining, red, black with age."

Type: "in lapidosis ad marginem laculorum salsorum prope Santa Cruz, Argentina," collected in 1882, *C. Spegazzini.*

Distribution: Terr. of Santa Cruz, southern Argentina, from the coast inland to Lake Buenos Aires.

Material seen:

Argentina: Patagonia andina, Terr. Santa Cruz, Rio Antiguos, am. Lag. Buenos Aires, Dec. 15, 1908, *Skottsberg 675* (ST); Puerto San Julian, Terr. Santa Cruz, coll. of 1925–27, *Blake 38* (KEW); Puerto San Julian, Terr. Santa Cruz, Patagonia, coll. of 1925–27, *Blake 39* (KEW); prope Santa Cruz, amporium in ripa argillosa lacusente, Dec. 23, 1904, *Dusén 5467* (ST); Terr. Santa Cruz, Golfo San Jorge, 1899–1900, *Ameghino 165* (BA); Terr. Santa Cruz, Nov. 25, 1929, alt. 200 m., *Donat 170* (MBG); Chubut, Valle del Rio Chico, Feb. 1930, *Ferruglio* (MBG).

As Spegazzini pointed out in his original description, this plant remotely suggests *L. capillare* Miers because of the glabrous condition of the filaments and corolla-tube, but it is very unlike that species otherwise. It appears to be rather closely related to *L. humile* of South America, and to *L. Fremontii* of North America, resembling the latter in flower size and shape and in calyx characters. Its decumbent habit and forked hairs set it off well from that species, however.

34. L. Fremontii Gray, Proc. Amer. Acad. **6**: 46. 1862; Bot. Calif. **1**: 543. 1876, and Syn. Fl. N. Amer. ed. 2, **2**^{1}: 239, 437. 1886; Jepson, Man. Fl. Pl. Calif. 891. 1925. Pl. 17, figs. 10–15.

L. gracilipes Gray, Proc. Amer. Acad. **12**: 81. 1877, and Syn. Fl. N. Amer. ed. 2, **2**^{1}: 239. 1886; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1287. 1924.

L. Fremontii Gray var. *gracilipes* Gray, Syn. Fl. N. Amer. ed. 2, **2**^{1}: 437. 1886.

L. pallidum β Fremontii Terrac. Malpighia **4**: 519. 1891.

L. pallidum β Fremontii var. *gracilipes* (Gray) Terrac. *l. c.*

A freely branching, stout, pubescent, somewhat glandular shrub 1–2 (3) m. tall; branches slightly curving, stout, unarmed, or with few slender, sharp spines 10–15 mm. long, grayish-yellow, glabrous to slightly pubescent, striate; leaves 3–5 in a fascicle, typically spatulate, 10–25 mm. long, 3–6 mm. broad, puberulent to densely pubescent, rounded, or less commonly acute or obtuse; pedicels 4–15 (25) mm. long, densely pubescent; calyx tubular, 4–8 mm. long (3 mm. in small flowers), 2–2.5 mm. in diameter, usually 5-lobed, the lobes triangular, about 1 mm. long; corolla tubular to funnel-form, deep violet or lavender to white with purple veins, 8–15 (18) mm. long, about 1.5–2 mm. in diameter at base, 2–3 mm. at summit, narrower in very small flowers, the 5 lobes $^1/_4$–$^2/_5$ the length of the tube, flaring, margins simply entire or sparsely and finely ciliate; stamens unequal, usually much shorter than corolla-lobes, rarely equalling the latter; anthers about 0.8 mm. long, or slightly longer; filaments adnate about $^2/_5$ the length of the corolla-tube, glabrous or with few scattered hairs at base of the free portion and above, adjacent corolla-tube glabrous or very sparingly pubescent; style about equalling or slightly exceeding the corolla-tube, sometimes much shorter than the stamens; stigma nearly 1 mm. broad; berry oblong-ovoid, 4–8 mm. thick and slightly longer, 40–60-seeded, red.

Type: interior of California or country east of it, coll. of 1849, *Fremont* (NY)—nearly identical with a plant collected in Santa Cruz Valley, Tucson, March 5, 1884, by C. G. Pringle.

Distribution: southern Arizona and the Imperial Valley of California, the islands and mainland of Baja California, and in northern Sonora, Mexico.

Material seen:

United States of America

Arizona: San Tan Mts., Pinal Co., Feb. 15, 1926, *Peebles 719* (US); San Tan, March 3, 1926, *Harrison 955* (US); Fish Creek, Apache Trail, Oct. 29, 1928, *Eastwood 15790* (CA); Camp Grant, Yuma Co., March 10, 1867, *Palmer 200* (G, MBG); near Dudleyville, March 13–Apr. 23, 1903, *Griffiths 3688* (US); Sacaton, Pinal Co., March 19, 1919, *Eastwood 8017, 8027* (CA), Feb. 24, 1930, *Peebles 6412* (US); on alkali land, Sacaton, March 15, 1930, *Peebles 6447, 6448, 6449* (MBG, P, SAC); Sacaton, Feb. 27, 1930, *Peebles 6429* (MBG, P, SAC); Sacaton, March 15, 1930, *Peebles 6452* (P, US), March 15, 1930, *Peebles 6450, 6451, 6453* (US), Apr. 29, 1927, *Peebles & Harrison 3970* (US), Feb. 3, 1931, *Peebles 7475* (MBG, P, SAC), Oct. 2, 1925, *Peebles, Harrison & Kearney 227* (US), Feb. 3, 1931, *Peebles 7478* (SAC); Sacaton Agency, Sacaton, March 22, 1902, *Thornber* (US); near Eloy, Pinal Co., March 16, 1926, *Peebles & Harrison 1166* (US); Santa Rosa to Casa Grande, Pinal Co., March 13–Apr. 23, 1903, *Griffiths 4042* (MBG, US); near Casa Grande, March 20, 1930, *Peebles & Harrison 6457* (US); near Casa Grande, March 20, 1930, *Peebles & Harrison 6459* (US); Roosevelt Dam, Gila Co., May 17, 1919, *Eastwood 8673* (CA); on road to Packard from Roosevelt, May 10, 1929, *Eastwood 17063* (CA); near Oracle, on road from Roosevelt to Tucson, May 25, 1929, *McKelvey 1128* (ST); Roosevelt Dam, May 20, 1917, *Mrs. J. F. Wilson* (C); on road from Oracle to Globe, Gila Co., May 25, 1929, *Eastwood 17475* (CA); between Roosevelt Dam and Packard, March 11, 1929, *McKelvey 875* (CA); Maricopa, Pinal Co., Apr. 22, 1917, *Eastwood 6321* (CA), May, 1885, *A. Gray* (G), Dec. 1881, *Parry* (F, G, MBG); Catalina Mts., Pinal Co., March 14, 1892, *Toumey 390* (S, US); Agua Caliente, March 19, 1914, *Carlson* (CA); Phoenix, Maricopa Co., Apr. 18, 1917, *Eastwood 6139* (CA), Apr. 18, 1917, *Eastwood* (CA), March 14, 1897, *Kunze* (NY); moderately alkaline soil near Phoenix, Aug. 30, 1901, *Kearney 122* (MBG, US); Tempe, Apr. 20, 1892, *Ganong & Blaschka* (G); Tempe, on way to Florence, Dec. 1900, *Griffiths 2224* (NY); Tempe, Apr. 6, 1894, *Toumey* (C, NY, US); river bank of the Gila near Dome, Yuma Co., Jan. 1916, *Monnet 1131* (CA, US); Parker Ferry, Yuma Co., March 22, 1931, *Har-*

rison, Kearney & Fulton 7528 (P, SAC); Tucson Mts., Jan. 2, 1920, *Bartram 236* (US); Tumamoc Hill, Tucson, Pima Co., Apr. 2, 1909, *S. B. Parish* (S); Tucson, coll. of 1911, *Beard* (MBG); Sabino Canyon, near Tucson, March 14, 1930, *Eastwood 17746* (CA); base of Signal Peak, Tucson, Dec. 24, 1919, *Bartram 260* (PA); from same locality, Jan. 5, 1920, *Bartram 234* (PA); Tucson, Nov. 1900, *Griffiths 2099* (NY); Santa Cruz bottoms near Tucson, March 13–Apr. 23, 1903, *Griffiths 4055* (MBG); Tucson, March 15, 1907, *Lloyd* (F), Apr. 11, 1884, *W. F. Parish* (C, NY, US), Apr. 1884, *S. B. & W. F. Parish* (C), Apr. 11, *W. F. Parish 180* (F, G, S); Pima Canyon, near Tucson, *S. B. Parish 8512* (S); Tucson, Jan. 23, 1881, *Parry* (MBG); Tucson Mts., Jan. 2, 1920, *Bartram 236* (PA); Santa Cruz Valley, Tuscon, March 5, 1884, *Pringle* (CA, D, F, G, NY, PA, US), Dec. 7, 1881, *Pringle* (CA, D, F, MBG, NY, PA, US); Tucson, Nov. 11, 1893, *Toumey 28* (US), Apr. 8, 1892, *Toumey 389* (US), May 1, 1894, *Toumey 191* (NY), Nov. 11, 1893, *Toumey* (US), Nov. 11, 1894, *Toumey* (C, DL, NY), March, 1881, *Vasey* (US), coll. of 1881, *Vasey* (F, G, MBG, US); Williams' Fork of Colorado R., March 11, 1876, *Palmer 423*, TYPE collection of *L. Fremontii* var. *gracilipes* (G TYPE, F, MBG, NY, US); Williams' Fork of Colorado River, coll. of 1876, *Palmer 422* (G, NY, PA, US); roadside, Western Canal, Salt River Valley, Maricopa Co., March 14, 1930, *Peebles 6444* (P, SAC); near Hyder, Yuma Co., Feb. 25, 1930, *Peebles 6428* (US); Colorado River bottoms, Yuma, Dec. 1, 1898, *W. F. Price* (S); Fort Mohave, Mohave Co., March 23, 1931, *Harrison, Kearney & Fulton 7558* (P, SAC); without definite locality, *Fremont Exped. Calif.*, 1849 (NY TYPE); Arizona, *Lemmon* (C); southern Arizona, coll. of 1873, *P. F. Mohr* (US).

CALIFORNIA: Split Mt., Colorado Desert, Apr. 1905, *T. S. Brandegee* (C); Borrego Springs, Colorado Desert, San Diego Co., Apr. 22, 1895, *T. S. Brandegee* (C); Boundary Monument 222, Colorado Desert, San Diego Co., between Calexico and Signal Mts., Apr. 2, 1903, *Abrams 3149* (F, G, MBG, NY, P, S); Signal Mt. March 30, 1901, *T. S. Brandegee* (C); Painted Canyon, Colorado Desert, March 24, 1928, *J. T. Howell 3530* (CA, S); San Felipe Canyon, Colorado Desert, San Diego Co., Apr. 13, 1913, *Eastwood 2785* (CA); wash in Santa Rosa Mts., Colorado Mts.,

alt. 150 m., Jan. 29, 1921, *Childs* (C); San Bernardino, possibility wrong locality?, *Lemmon* (C); San Diego, Dec. 1908, *Dudley* (S); west end of Santa Rosa Is., July 9, 1930, *Hoffmann* (CA, P).

Mexico

Baja California: gravel mesas, Cucopa Mts., Apr. 5, 1905, *MacDougal 140* (NY); the three following collections have pubescent corolla-tubes: Magdalena Is., Jan. 13, 1889, *T. S. Brandegee* (C); Santa Margarita Island, March 2, 1889, *T. S. Brandegee* (C), March, 1889, *T. S. Brandegee* (C).

Sonora: vicinity of Hermosillo, March 6, 1910, *Rose, Standley & Russell 12443* (NY, but not that specimen in US); Sonora, *Schott* (F); dry plain, vicinity of Empalme, March 11, 1910, *Rose, Standley & Russell 12621* (US); Sonoyta River, at Santo Domingo, Jan. 14, 1894, *Mearns 2717* (US); Sonoyta, Jan. 19, 1894, *Mearns 2733* (NY, S, US).

Lycium Fremontii is rather remarkable among the North American species because of the unusual length of the calyx-tube, *L. exsertum* being the only other species from this hemisphere which approaches it in this respect. *Lycium repens* and *L. humile* are the South American species most closely related to it. The flowers are strikingly dimorphic, one type having a tubular corolla, which is but one and one-half the length of the calyx, the other extreme having a funnelform corolla fifteen millimeters in length, the tube being much flared at the summit, and the anthers frequently but partially developed. This variation may be due at least in part to the age of the plant—flowers from old branches usually being reduced in size, whereas the leaves and flowers of young, vigorously growing branches are sometimes twice the size of the former.

A series of specimens collected by Mr. Peebles is especially interesting in this connection: His number 6428, collected near Hyder, Arizona, is a very young shoot having extremely large flowers, and number 6452, from Sacaton, is also a young shoot which has flowers that would almost seem to belong to a different species when first seen. Peebles and Harrison no. 6457, from near Casa Grande, has flowers on the lower portion which resemble those of the above plant—on the upper portion, however, they are smaller, the corolla is narrower and presents an entirely

different aspect, being much like the flowers on the specimen of Peebles and Harrison no. 6459, from the same locality. The flowers on this plant represent the other extreme, in that the branches are old, the leaves are small, and the corollas are only about 8 mm. long. The stigma is exserted because of the fact that the corolla-lobes are revolute. The tubular calyx and included stamens (which are but very sparsely pubescent at base) are typical.

The corolla-size, the length of the lobes, leaf-size, pubescence, and stigma length all vary, so that the specimens cited include a wide range of variation. Because of the fact that *L. Fremontii* is such a protean species, it is deemed best to adopt a rather conservative viewpoint in delimiting subordinate groups, but even so, there is one well-marked group which must be given varietal rank.

34a. L. Fremontii var. **congestum** C. L. Hitchcock, nom. nov.

L. umbellatum Rose, Contr. U. S. Nat. Herb. **1**: 74. 1890; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1287. 1924; I. M. Johnst. Proc. Calif. Acad. Sci. IV, **12**: 1154. 1924.

Branches pale green, exceedingly pubescent; leaves oblong-obovate, less commonly spatulate, blade 1.5–3 cm. long, nearly ½ as broad, petiole nearly ½ as long as blade, densely pubescent, somewhat viscid; lobes of corolla densely ciliate; filaments rather densely pubescent just above point of adnation; berry nearly 1 cm. long.

Type: La Paz, Lower California, between January 20 and February 5, 1890, *Palmer 13* (US).

Distribution: Baja California and Sonora, Mexico.

Material seen:

MEXICO

WITHOUT LOCALITY: *T. S. Brandegee* (C), distributed as "L. umbellatum Rose? ex char."

BAJA CALIFORNIA: La Paz, Feb. 3, 1906, *Nelson & Goldman 7488* (MBG, US); La Paz, Jan. 20–Feb. 5, 1890, *Palmer 13* (US TYPE, G, NY); La Paz, coll. of 1927, *Jones 24159* (C, MBG, P); La Paz, Apr. 11, 1921, *Johnston 3040* (CA, G, US); road to Cerro Colorado from Agua Colorado, alt. 30–150 m., Dec. 15, 1905, *Nelson & Goldman 7322* (US).

Sonora: vicinity of Hermosillo, March 6, 1910, *Rose, Standley & Russell 12441* (NY, US).

There seems to be but little justification for maintaining this variety as specifically distinct from *L. Fremontii*, the chief differences being the larger size and more dense pubescence of all parts.

Rose's species was antedated by *L. umbellatum* of Ruiz and Pavon,[57] which is a different plant.

35. L. exsertum Gray, Proc. Amer. Acad. **20:** 305. 1885; Syn. Fl. N. Amer. ed. 2, **2**[1]: 437. 1886; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23:** 1286. 1924. Pl. 17, figs. 16–18, 22–27.

L. Fremontii var. *Bigelovii* Gray, Proc. Amer. Acad. **6:** 47. 1862; Bot. Calif. **1:** 543. 1876, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 239. 1886.

L. retusum Rob. & Fern. Proc. Amer. Acad. **30:** 120. 1894; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23:** 1287. 1924.

L. pallidum β Fremontii var. *Bigelovii* (Gray) Terrac. Malpighia **4:** 520. 1891.

L. pallidum β Fremontii var. *gracilipes* subvar. *exsertum* (Gray) Terrac. *l. c.*

A rather sparingly branched, few-spined, densely pubescent shrub 1–3.5 m. tall; branches rigid, densely pubescent, apparently very glandular when young, gray to reddish-brown when mature, spines slender, sharp, 3–7 (10) mm. long; leaf-blades spatulate to obovate-spatulate, 0.5–2 (4) cm. long, 3–5 (10) mm. broad, rounded or obtuse, less commonly acute, attenuate to a petiole 3–5 mm. long, densely and finely pubescent, somewhat glandular-viscid, midnerve evident; flowers borne singly, or more commonly in 2's or 3's, pedicels 3–5 mm. long, densely viscid-pubescent, usually recurved and flowers pendent; calyx tubular-campanulate, 2.5–6 mm. long, densely pubescent, lobes 5, acutely deltoid, ⅓–½ the length of the tube, equal, or irregularly lobed and more or less 2-lipped, in which case some of the lobes may be as long as the tube; corolla-tube whitish to brownish, obconic, narrowed slightly above ovary, (6) 10–14 mm. long, about 4 times as wide at top as at base, glabrous without, lobes 5, pale lavender, oval,

[57] Ruiz and Pavon, Fl. Peruv. **2:** 45. 1799.

about 1/6 length of tube, rotate or deflexed, retuse or rounded at apex, edges usually revolute, glabrous or very sparsely ciliolate; stamens subequal, exserted 2–3 mm. or more from corolla-tube, except when non-functional, filaments adnate to corolla-tube for about 1/5 its length, lower 2/3 of their free portion thickly hairy, corolla-tube less dense-hairy from top of ovary to a point about 2/3 way from base, anthers 1.5–2 mm. long; style usually slightly shorter than stamens, and only slightly exserted but sometimes exserted 2–4 mm., frequently sparingly hairy near stigma; ovary ovoid, 6–7 mm. long, 20–30-seeded.

Type: near Altar, northwestern Sonora, Mexico, March 22, 1884, *Pringle* (G).

Distribution: southern Arizona, and the northern portions of the states of Baja California, Sonora, and Sinaloa, Mexico.

Material seen:

UNITED STATES OF AMERICA

ARIZONA: Roosevelt, March 31, 1928, *Peebles, Harrison & Kearney 5217* (US); on road between Sonoita and Vail, March 18, 1920, *Eastwood 17795* (CA); near Magma, Pinal Co., Feb. 28, 1930, *Peebles & Loomis 6430* (MBG, P, US); Sabino Canyon, March 20, 1897, *Zuck* (US); Sierra Estrella, Oct. 17, 1926, *Peebles, Harrison & Kearney 3288* (US); Sacaton, Feb. 3, 1931, *Peebles 7476* (MBG, P, SAC), Feb. 3, 1931, *Peebles 7467* (P, SAC); San Tan Mts., Feb. 1, 1931, *Peebles & Loomis 7456, 7457, 7458* (MBG, P, SAC); Baboquivari Canyon, Pima Co., Feb. 10, 1931, *Peebles 7486* (MBG, P, SAC); Fresnal, Papago Indian Reservation, Pima Co., Feb. 10, 1931, *Peebles 7487* (P, SAC); Sacaton Mts., Pinal Co., Jan. 11, 1931, *Peebles & Loomis 7451* (MBG, P); San Tan Mts., Feb. 24, 1930, *Peebles & Miller 6417* (P, US); base of cliffs, Jan. 27, 1929, *Peebles 9841* (US); Tucson, March 3, 1894, *Toumey* (C, DL, NY); March 20, 1897, *Zuck* (US); on road to Rincon Mts., March 19, 1930, *Eastwood 17826* (CA); on road to Rincon Mts., from Tucson, March 20, 1930, *Eastwood 17863* (CA).

MEXICO

BAJA CALIFORNIA: Calmilli, *Purpus 155* (C, NY, P); San Gregorio, Feb. 2, 1889, *T. S. Brandegee* (C); Cedros Is., Apr. 1, 1897, *T. S. Brandegee* (C), Apr. 4, 1897, *T. S. Brandegee* (C), with some doubt.

Sonora: March 22, 1884, *Pringle* (D, F, G type, NY, PA, US).

Sinaloa: vicinity of Culiacan, Oct. 10, 1904, *T. S. Brandegee* (G).

In discussing this species in the 'Synoptical Flora,' Gray said: "Very much like the last preceding" (*L. Fremontii*). On one of the sheets in the United States National Herbarium there is a notation by Mr. T. H. Kearney regarding the relationship of the two: "I am not sure, however, that *exsertum* is specifically distinct from *Fremontii* . . . if these forms of *Lycium* are dimorphic as to length of stamens and pistil, the character on which *L. exsertum* was mainly based loses its importance." The stamens in *L. Fremontii* do vary in length; in some instances they may even be exserted slightly, but the extreme length of those in *L. exsertum* far surpasses that of any specimen of *L. Fremontii*, and it appears clear that the two are very definite species. Besides the difference in stamen length there are several characters that are of value in separating the two. The calyx-tube of *L. exsertum* is much shorter in proportion to its lobes, and is more campanulate than tubular. The margins of the corolla-lobes in *L. exsertum* are practically without hairs, but are ciliate in *L. Fremontii*. The corolla-tube is more flaring in *L. exsertum*, and the general aspect of the two plants is usually quite dissimilar. Another character which is distinctive between the two is the great amount of pubescence on the filaments of *L. exsertum*. *Lycium Fremontii* has much less pubescence on the filaments, and in some cases, practically none.

The plant which Gray described as *L. Fremontii* var. *Bigelovii* is the same as *L. retusum* Robinson and Fernald, and both plants are undoubtedly but a form of *L. exsertum*. Had it not been for the advice of Mr. Peebles, who is making a very careful study of this species in the field, the writer would have made the same error Dr. Gray made when he referred material of this kind to varietal rank under *L. Fremontii*.

The following collections are of this nature, and may be unquestionably referred to *L. exsertum*:

United States of America

Arizona: Santa Rita Mts., Aug. 24, 1903, *Jones* (P); on road to Rincon Mts., from Tucson, March 20, 1930, *Eastwood 17864*

(CA); on road to Rincon Mts., from Tucson, March 19, 1930, *Eastwood 17815* (CA); Casa Grande, Gila Bend road, north of Table Top Mt., Pinal Co., March 2, 1930, *Fulton 6435* (MBG, P, SAC); San Tan Mts., Feb. 1, 1930, *Peebles & Loomis 7464* (P, SAC); San Tan Mts., Feb. 23, 1930, *Peebles 6404* (MBG, P, US); Tucson Mts., Jan. 21, 1920, *Bartram 232*, glabrate plant (PA); near Tucson, Feb. 2, 1903, *Coville 1616* (US); Sierra Estrella, Pinal Co., Feb. 16, 1930, *Peebles 6397* (MBG, P, US); Sierra Estrella, Feb. 16, 1930, *Peebles 6392* (MBG, P, US); Fresnal, Papago Ind. Reservation, Feb. 9, 1931, *Peebles 7485* (SAC); on road between Sonoita and Vail, Pima Co., March 18, 1930, *Eastwood 17794* (CA); Sabino Canyon, Santa Catalina Mts., Pima Co., Jan. 3, 1920, *Bartram 233* (PA, US); Santa Catalina Mts., Feb. 22, 1901, *Griffiths 2290* (NY); Tucson, March 3, 1894, *Toumey* (US); infrequent, washes, near Baboquivari Mts., Pima Co., Feb. 24, 1923, alt. 1000 m., *Hanson & Hanson A1025* (F, MBG, PA); Bill Williams' Fork, Yuma Co., Feb. 8, 1854, *Bigelow* (G TYPE *L. Fremontii* var. *Bigelovii*, NY); Tucson, March 22, 1919, *Eastwood 8117* (CA); between Roosevelt Dam and Packard, March 11, 1929, *McKelvey 878* and *879* (CA).

MEXICO

SONORA: Oputo, Nov. 1, 1890, alt. 1100 m., *Hartman 212*, TYPE collection of *L. retusum* (G TYPE, US).

36. L. pallidum Miers, Ann. & Mag. Nat. Hist. II, **14**: 131. 1854, and Ill. S. Amer. Pl. **2**: 108, *pl. 67C*. 1857; Gray, Proc. Amer. Acad. **6**: 45. 1862, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 238. 1886; Hemsl. Biol. Cent.-Am. Bot. **2**: 426. 1882; Coult. Contr. U. S. Nat. Herb. (Bot. W. Tex.) **2**: 302. 1892; Woot. & Standl. Contr. U. S. Nat. Herb. (Fl. N. Mex.) **19**: 569. 1915; Bailey, Cycl. Hort. **4**: 1930. 1916; Rydb. Fl. Rocky Mts. 758. 1917; Tidestrom, Contr. U. S. Nat. Herb. (Fl. Utah & Nev.) **25**: 471. 1925; Jepson, Man. Fl. Pl. Calif. 890. 1925. Pl. 18, figs. 6–7.

L. Schaffneri Gray in Hemsl. Biol. Cent.-Am. Bot. **2**: 426. 1882; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1286. 1924.

L. pallidum α normale Terrac. Malpighia **4**: 519. 1891.

L. Berlandieri α normale var. *Schaffneri* (Gray) Terrac. *l. c.* 520.

A densely branched, spreading, spiny shrub 1–2 m. tall; branches often somewhat flexuous, yellow, gray, or more commonly reddish to purple, glabrous or rather sparsely pubescent, spines slender, sharp, 0.5–1 cm. long, the longer ones usually somewhat blunt; leaves glaucous-green, glabrous or glabrate, oblong-spatulate to broadly elliptic, or nearly ovate, acute or occasionally rounded, 1–4 cm. long, 3–15 mm. broad, attenuate at base into a short petiole, midnerve and primary lateral nerves usually visible; flowers borne singly or in pairs, pedicels equalling or slightly exceeding the calyx; calyx cup-shaped to campanulate, blue-glaucous and glabrous, 5–8 mm. long, ⅔ as broad at summit, 5-lobed, the lobes lanceolate to ovate or elliptic, equalling or even exceeding the tube, their margins sometimes sparsely pubescent; corolla-tube elongate-funnel-form, 12–20 mm. long, about 1.5 mm. in diameter above the ovary, 5–6 mm. in diameter at top where it is expanded conspicuously, greenish with purple veins, often blue-glaucous on outside, the 5 lobes oval or rhombic, $^1/_5$–$^1/_3$ the length of the tube, their margins commonly very remotely ciliolate; stamens usually slightly exserted, sometimes extending only to the base of the corolla-lobes, filaments adnate to a little below the middle of the corolla-tube, free base of the filaments and the adjacent corolla-tube hairy, anthers 1.5 mm. long; style varying in length from about equal to corolla-tube to 4 or 5 mm. longer than tube; berry red or reddish-blue due to glaucescence, ovoid, about 1 cm. or slightly less in diameter, 20–50-seeded.

Type: Santa Fe Creek Valley, New Mexico, May, June, 1847, *Fendler 670* (British Museum).

Distribution: western Texas, southern Colorado, New Mexico, Arizona, southern Utah, and the states of Sonora, Chihuahua, Zacatecas, and San Luis Potosi, Mexico.

Material examined:

United States of America

Locality uncertain: *Mex. Bound. Surv. 1027* (US); valley near Croton Spring, Mex. Bound. Surv., Sept. 9, 1858, *Hayes* (NY); agricultural grounds, Washington, *Dr. Vasey* (G, US); Pacific slope, *Lemmon* (C); Oryabe, on Ives' Colorado Expedition, May 13, *Newberry* (G).

TEXAS: Boquillas, Brewster Co., May 28, 1901, *Bailey 357* (US); Davis Mts., Jeff Davis Co., Apr. 29, 1902, *Tracy & Earle 342* (D, F, G, MBG, NY, US).

COLORADO: without locality, *T. S. Brandegee*, coll. of 1878 (US); Trinidad, Las Animas Co., June 13, 1916, *Eastwood 5540* (CA); McElmo Creek, Montezuma Co., May, 1892, *Eastwood 6108* (NY, S); dry rocky flat, Cortez, Montezuma Co., Aug. 30, 1919, *Payson 1124* (MBG); valley of the San Juan, W. Colorado, July, 1875, *T. S. Brandegee 1084* (C, MBG); Bayfield, La Plata Co., June 5, 1907, *Gary 175* (US).

NEW MEXICO: Puoje Indian Ruins, Oct. 14, 1928, *Eastwood 15549* (CA); bottom-land of Santa Clara River, western New Mexico or southern Utah?, May 11, 1843–44, *Fremont 474* (NY); without locality, *Fendler*, coll. of 1863 (F); Arizona or N. Mex., coll. of 1847, *Fendler 668b* (G); without locality, *Ellis 469* (MBG); without locality, May, 1851, *Thurber 288* (F, G, NY); New Mexico or Arizona, *Rusby* (MBG); Ojo Caliente, July 20, 1894, alt. 2000 m., *B. H. Smith* (PA); El Puerco, coll. of 1874, *Rothrock 90* (F); between Barranca and Embudo, Taos Co., May 27, 1897, alt. 2000 m., *Heller & Heller 3599* (G, MBG, NY, P, S, US); Ojo Caliente, Taos Co., July 28, 1904, *Wooton 2683* (US); 1 mi. w. of Hillsboro, Sierra Co., Apr. 29, 1905, alt. 1800 m., *Metcalfe 1590* (CA, D, F, G, MBG, NY, P, US); dry hills, vicinity of Cedar Hill, San Juan Co., Aug. 16, 1911, alt. 1900 m., *Standley 7946* (US); Gallup, McKinley Co., June 14, 1916, *Eastwood 5594* (CA); Gallup, July 20, 1897, *Herrick 894* (US); south of Gallup, Aug. 1, 1904, *Wooton* (US); Thoreau, McKinley Co., June 11, 1909, alt. 7400 m., *Goldman 1586* (US); Ft. Wingate, McKinley Co., coll. of 1883, and of 1882, *Dr. Mathews* (G); Bear Canyon, Sandia Mts., Sandoval Co., May, 1898, *Herrick 263* (US); Sandia Mts., coll. of 1914, *Ellis 150* (US); Santa Fe, June 15, 1899, *Diehl* (P); Santa Fe Creek Valley, May–June, 1847, *Fendler 670*, TYPE collection (F, G, NY, MBG); on the mesa about 2 miles east of Albuquerque, Bernalillo Co., coll. of 1915, alt. 1500 m., *Kammerer 25* (MBG); La Luz Canyon, Lincoln Forest, Otero Co., June 20–23, 1918, alt. 2000 m., *Eggleston 14363* (G, US); Dog Spring, Dog Mts., Otero Co.?, Sept. 16, 1893, *Mearns 2327* (US); Dog Spring, June 12, 1892, *Mearns 304* (US); 30 miles west of Roswell, Chaves Co.,

June 16, 1899, *Bailey 139* (US); Carrizo Mts., Lincoln Co., May–June, 1892, *Dr. Mathews* (US); near Nogal, Lincoln Co., July 24, 1901, *Wooton* (US); Gray, Lincoln Co., May 12, 1898, alt. 2000 m., *Skehan 12* (D, G, MBG, NY, P, US); juniper belt, Capitan, Lincoln Co., May 8–19, 1902, *Earle 637* (NY); Mangas, Catron Co., June, 1897, *Metcalfe 2* (US); east side of Rio Hondo Valley, San Miguel Co., June 15, 1930, alt. 1300 m., *Goodman & Hitchcock 1136* (MBG); Silver City, Grant Co., May 9, 1906, *Bailey* (US); Silver City, May 1, 1919, *Eastwood 8390* (CA); near Santa Rita del Cobre, Grant Co., coll. of 1877, *E. L. Greene* (F); Bear Mt., near Silver City, Grant Co., May 1, 1902, alt. 1500 m., *Metcalfe 42* (C, D, G, MBG, NY, P, S, US); Fort Bayard, Grant Co., Aug. 2, 1895, *Mulford 603* (MBG); Bear Tooth Ridge, Fort Bayard Watershed, Nov. 24, 1905, alt. 2000 m., *Blumer 188* (G, NY, US); Organ Mts., Dona Ana Co., Apr. 30, 1893, *Wooton* (US); Van Pattens, Organ Mts., Apr. 25, 1895, *Wooton* (US); Van Pattens, Organ Mts., July 14, 1895, *Wooton* (US); Deming, Luna Co., Apr. 10, 1911, *Treakle* (P); 10 miles west of Deming, June 16, 1930, *Goodman & Hitchcock 1150* (MBG).

Arizona: Cal-Ariz., coll. of 1876, *Palmer* (G); without locality, *Palmer*, coll. of 1869 (PA, US), *Millspaugh 213* (G), *Millspaugh 206* (F); N. Arizona, *Lemmon 3245* (G); N. E. Ariz., Fewkes Expl. Exp. of 1896, Aug. 1–Sept. 5, 1896, *Hough 71* (US); Arizona, June, 1929, *Driver & Driver* (SBM); without locality, *Voth 122* (F); near Dudleyville, March 13–Apr. 23, 1903, *Griffiths 3683V, 3681* (US); hills above Rosemont, March 13–Apr. 23, 1903, *Griffiths 4130* (MBG, US); San Francisco River, Aug. 8, 1881, *Rusby 306* (MBG, US); Moki, Aug. 20, 1897, *Zuck* (US); Fort Whipple, May 3, 1865, *Coues, Elliott & Palmer 361* (G, MBG); on gravelly hillside, Fort Whipple, May 3, 1865, *Coues, Elliott & Palmer 190* (MBG); Turquoise, May 14, 1894, *W. W. Price* (S); sandy wash, 17 miles south of Animas, Animas Valley, July 9, 1928, *Wolf 2581* (CA); Cosnino, July 8, 1884, *Jones* (P); Las Cabezas, July, 1894, *Fisher 2807* (US); Verde Valley, Apr. 7, 1920, *W. W. Jones 75* (G); Middle Verde, Apr. 8, 1921, *W. W. Jones* (C); Fort Verde, Apr. 11, 1888, *Mearns 349* (NY); Sanvita Valley and Patagonia Mts., Apr. 1881, *Lemmon 217* (C); Sanvita Valley, Apr. 1881, *Lemmon* (D, F); Walnut Grove, Apr. 28, 1876, *Palmer 419* (C, F,

G, MBG, NY, US); Hassayampa River Valley, Apr. 1876, *Palmer* (NY); 6 miles south of Benson, June 20, 1930, *Goodman & Hitchcock 1237* (MBG); Clifton, Greenlee Co., Apr. 1877, *Davidson 164* (C); Duncan, Greenlee Co., spring of 1920, *Durant* (P); along road from Roosevelt to Globe, Pinal Co., May 24, 1929, *Eastwood 17447a* (CA); between Roosevelt and Globe, May 18, 1929, *McKelvey 1077* (ST); near Fort Huachuca, Cochise Co., June, 1894, *Wilcox 187* (US); Ft. Huachuca, May, 1892, *Wilcox* (NY, US), coll. of 1894, *Wilcox* (MBG); Bajada of Whetstone Mts., Cochise Co., Apr. 15, 1917, *Shreve 5161* (C, DL, G, US); Quitobasquita, Pima Co., Jan. 28, 1894, *Mearns 2740* (S, US); San Carlos, Gila Co., June 23, 1904, *Coville 1903* (US); Buckskin Mts., Yuma Co., June 19, 1890, *Jones* (P); mesa, 2 miles east of Springerville, Apache Co., July 4, 1914, *Ferris 1229* (CA, S); Navajo Reservation, July, 1916, *Herb. U. of Ariz.* (MBG, US); dry hills, north end of Carrizo Mts., July 30, 1911, *Standley 2435* (US); Navajo Reservation, July, 1916, *Vorhies 83* (C, G); Holbrook, Navajo Co., Oct. 9, 1897, *Zuck* (MBG, NY, US); Walnut Canyon, near Flagstaff, Coconino Co., July 11, 1923, alt. 2000 m., *Hanson & Hanson A641* (MBG); 9 miles northeast of Flagstaff, June 4, 1913, alt. 2200 m., *Goldman 2053* (US); Flagstaff, *Purpus* (P), May, Oct. 1900, *Purpus 7091* (C, MBG, P, US); rocky ledge, near Cameron, Coconino Co., June 17, 1922, *Hanson A130* (MBG, US); San Francisco Mts., Coconino Co., Sept. 5, 1889, *Knowlton 214* (US); cinder cones east of San Francisco Mts., June 1, 1891, *McDougal* (US); Red Lake, desert near Tuba, Coconino Co., July 15–31, 1920, *Clute 4* (G, MBG, NY, US); Little Colorado River, Aug. 1896, *Fernon* (US); 1 mile east of Prescott, Yavapai Co., June 28, 1928, *Wolf 2366* (CA); Ash Fork, Yavapai Co., June 18, 1901, *Barber 102* (US); between Prescott and Ash Fork, Apr. 26, 1930, *Loomis 6908* (US); Cherry Creek Road to Prescott, June 1, 1929, *Eastwood 17625* (C, CA); along road from Prescott to Ash Fork, Nov. 8, 1928, *Eastwood 16752* (CA); Skull Valley, Yavapai Co., Apr. 28, 1903, alt. 1200 m., *Jones* (MBG, P, US); Peach Springs, Mohave Co., May, 1893, *Wilson 178* (S, US); Yucca, Mohave Co., May 14, 1884, *Jones 3903* (C, D, F, NY, P, US).

UTAH: Beaverdam Mts., May 11, 1891, *Bailey 1951* (US);

without locality, *Vasey* (F); Bluff, San Juan Co., July 1, 1927, *Cottam 2520* (GAR); sand dunes, Bluff, July 2, 1927, alt. 1300 m., *Cottam 2543* (GAR); along San Juan R., near Bluff, July 25–29, 1911, alt. 1200–1500 m., *Rydberg & Garrett 9975* (GAR, NY); Allen Canyon, southwest of Abajo Mts., San Juan Co., July 30–31, 1911, alt. 1800–2000 m., *Rydberg & Garrett 9295* (NY); Armstrong and White Canyons, near the Natural Bridge, Aug. 4–6, 1911, alt. 1600–1800 m., *Rydberg & Garrett 9396* (NY); Virgin, Washington Co., Apr. 24, 1930, alt. 1500 m., *Cottam C4795* (GAR); open prairies and lowlands, Diamond Valley, May 19, 1902, *Goodding 878* (D, G, MBG, US); Belleview, Apr. 21, 1888, *Jones* (MBG, P); St. George, May 14, 1894, *Jones 5215a* (P, US); St. George, coll. of 1877, *Palmer 367* (G, MBG, NY, US); red sand, Rockville, May 15, 1894, alt. 1100 m., *Jones 5224t* (P, US); Zion Canyon, May 7, 1923, *Jones* (P); mesa at Kanab, June 25, 1909, alt. 1480 m., *Tidestrom 2304* (US).

MEXICO

SONORA: without locality, Sept. 1851, *Thurber* (F); Los Ranchos, vicinity of Guaymas, Apr. 23, 1910, *Rose, Standley & Russell 15031* (US).

CHIHUAHUA: Ojo de Vaca, June 1851, *Thurber 110* (G, NY).

ZACATECAS: on the road to Huejuquilla near San Juan Capistrano, Aug. 23, 1897, *Rose 2488* (US).

SAN LUIS POTOSI: 22° N. lat., coll. of 1878, alt. 2000 m., *Parry & Palmer 655* (G, MBG, PA, US); "ex convalli San Luis Potosi, Sept.–Oct. 1877," *Schaffner 54*, TYPE of *L. Schaffneri* (G); San Luis Potosi, coll. of 1879, *Schaffner 409* (NY, US); "in montibus," San Luis Potosi, Aug. 1879, *Schaffner 418* (CA, NY, US); San Luis Potosi, *Schaffner 419, 420* (F); ex convalli San Luis Potosi, coll. of 1876, *Schaffner* (G).

36a. L. pallidum var. oligospermum C. L. Hitchcock, var. nov.[58]

Leaves 10–20 mm. long, 3–5 mm. broad; corolla, including lobes, seldom over 20 mm. long; filaments usually densely hairy nearly to top of corolla-tube; berry 6–7 mm. in diameter, 4–8 (usually 4 or 5)-seeded, bluish; seeds 2.5–4 mm. long.

[58] **L. pallidum** Miers var. **oligospermum** C. L. Hitchcock, var. nov.; foliis 10–20 mm. longis, 3–5 mm. latis; corolla 15–20 mm. longa; bacca 4–8-sperma. Collected at Barstow, San Bernardino Co., California, March 5, 1916, alt. 700 m., *Jepson 6606* (Missouri Botanical Garden Herbarium, no. 836303 TYPE, C, S, US).

Type: Barstow, San Bernardino Co., California, March 5, 1916, alt. 700 m., *Jepson 6606* (MBG).

Distribution: Mohave Desert of California and adjacent Nevada.

Material seen:

United States of America

California: Death Valley, Inyo Co., March 11, 1924, *Jones* (P); Ballarat Grade, Inyo Co., Apr. 2, 1929, *Hoffmann* (SBM); Victorville, San Bernardino Co., March 13, 1927, *Hart* (CA); Barstow, San Bernardino Co., June 4, 1912, alt. 700 m., *Jepson 4779* (S), May 30, 1914, *Jepson 6148* (C, MBG); March 5, 1916, alt. 700 m., *Jepson 6606* (MBG type, C, S, US); 5 miles west of Barstow, March 9, 1914, *Minthorn* (C); stony hills, Garlic Spring, San Bernardino Co., Apr. 25, 1930, *Hoffmann* (SBM); 4 mi. n. of Trona, Inyo Co., Apr. 15, 1932, *Munz & Hitchcock 12284* (P).

Nevada: Rhyolite, Apr. 11, 1907, alt. 1200 m., *M. E. Jones* (CA, P, S).

Lycium pallidum and its variety may be separated easily from all other American species by the large glaucous leaves, and large, funnel-form corolla. *Lycium Cooperi* is the only species with which it is apt to be confused. The rather dense pubescence and the peculiar "horn-like" lobes of the fruit of the latter species serve adequately to distinguish the two.

37. L. Cooperi Gray, Proc. Amer. Acad. **7**: 388. 1868; Bot. Calif. **1**: 542. 1876, and Syn. Fl. N. Amer. ed. 2, **2**^{1}: 238. 1886; Rydb. Fl. Rocky Mts. 758. 1917; David. & Moxl. Fl. S. Calif. 321. 1923; Jepson, Man. Fl. Pl. Calif. 891. 1925; Tidestrom, Contr. U. S. Nat. Herb. (Fl. Utah & Nev.) **25**: 471. 1925.

Pl. 18, figs. 4–5; pl. 13, fig. 6.

L. Cooperi var. *pubiflora* Gray, Syn. Fl. N. Amer. ed. 2, **2**^{1}: 238. 1886.

L. pallidum α normale var. *Cooperi* (Gray) Terrac. Malpighia **4**: 519. 1891.

L. pallidum α normale var. *Cooperi* forma *pubiflora* (Gray) Terrac. *l. c.*

L. Shockleyi Gray, Proc. Amer. Acad. **22**: 311. 1887.

A stout, spiny, densely branching, heavy shrub 0.7–2 m. tall;

branches thick and rigid, silver to purplish or tan when old, densely pubescent when young, spines short, thick, 3–10 mm. long, blunt; leaves 3–10 in a fascicle, spatulate to obovate-spatulate or oblanceolate, 1–3 cm. long, 0.4–1.0 cm. broad, rounded to truncate at the apex, attenuate at base, glabrate to densely glandular-pubescent or hispidulous, midnerve and some of the lateral nerves usually evident; flowers numerous, 1–3 in a fascicle, borne on pedicels which are about same length as the calyx; calyx bowl-shaped or oblong-campanulate, 8–15 mm. long, ⅓–⅔ as broad, glabrate, or much more commonly, glandular-hispidulous, lobes (4) 5, triangular to shortly ovate-lanceolate, from ½ as long to about the length of the tube, expanding with the growth of the fruit and at length usually ruptured; corolla greenish-white with lavender veins, persistent until the ovary is well developed, tube 8–15 mm. long, nearly cylindric, slightly expanded at top, from densely pubescent to glabrous exteriorly, lobes (4) 5, $^1/_5$–$^1/_4$ the length of the tube, ovate-triangular, rotate or reflexed, margins usually ciliate; stamens (4) 5, about equalling corolla-tube, or slightly included, filaments equal or subequal, adnate to near the middle of the corolla-tube, free bases of filaments and the vascular strands leading to them covered with long, spreading white hairs, anthers 1 mm. long, or slightly longer; style about equalling stamens, or shorter than they; fruit 5–9 mm. long, frequently 3-carpellary, ovoid, with a wedge-shaped apex, lateral constriction present somewhat above middle, forming 2 compartments nearly separated from one another, 1 (2) seeds in upper half, several (5–8) in lower, wall sclerenchymatous, especially in upper half, greenish-yellow.

Type: eastern slope of Providence Mts., San Bernardino Co., California, May 29, 1861, *Cooper* (G).

Distribution: Mohave and Colorado Deserts of California, eastward to Yuma, Arizona, and northward to Esmeralda County, Nevada, and southwestern Utah.

Material seen:

United States of America

Arizona: Oatman-Kingman road, Mohave Co., March 23, 1931, *Harrison, Kearney & Fulton 7614* (P, SAC); Yucca, Yuma Co., March 12, 1912, *Wooton* (US); Mica Springs, Apr. 13, 1894,

alt. 1100 m., *Jones 5045af* (P, US); east of Fort Mohave, Apr. 8, 1884, *Lemmon* (C); Ft. Mohave, Apr. 1884, *Lemmon & Lemmon* (C, D); southeastern California or Arizona, coll. of 1876, *Palmer 66* (G); Beaverdam, northwestern Arizona, coll. of 1877, *Palmer 364* (G, NY, US); Apr. 5, 1894, alt. 600 m., *Jones 5012* (C, MBG, P, US).

UTAH: desert near Walker River, June 9, 1889, *H. Engelmann* (MBG).

NEVADA: open sand, Candelaria, May 14, 1882, *Shockley 219* (C, G TYPE of *L. Shockleyi*, NY, S, US in part); Gold Mt., Esmeralda Co., June 3, 1891, *Bailey 2005* (US); Meadow Valley Wash, Apr. 6, 1905, *Goodding 2160* (G, MBG); Good Springs, Apr. 30, 1905, *Jones* (P); Hawthorne, Apr. 22, 1907, alt. 1600 m., *Jones* (P).

CALIFORNIA: June 9, 1889, *Simpson's Exped.* (MBG); Mohave Desert, May 18, 1882, *Pringle* (D, F, G, NY, PA, US); Mohave Desert, coll. of 1895, *Davidson* (C), Apr.–May, 1906, *Saunders* (PA); 6 miles from Darwin on road to Owen's Valley, Inyo Co., June 11, 1930, *Ferris 7912* (C); in canyon, Darwin, Keeler Road, 10 miles from Keeler, Inyo Co., Apr. 29, 1928, *Ferris 7432* (NY); Darwin Mesa, June 11, 1891, alt. 1500 m., *Coville & Funston 907* (US); Willow Creek Canyon, Panamint Mts., May 22, 1891, *Coville & Funston 826* (US); Mountain Spring Canyon, Inyo Co., May 8, 1929, *Hoffmann* (SBM); near Crystal, Cosa Mts., Inyo Co., June 12, 1891, alt. 1830 m., *Coville & Funston 929* (US); sandy flat, 15 miles north of Muroc, Kern Co., Apr. 27, 1929, *Hoffmann* (SBM); region of Tehachapi Peak, June, 1895, alt. 2300 m., *Dudley* (S); Maricopa Hills, Kern Co., March 15, 1913, *Eastwood 3274* (CA, G, US); rocky hills between Rosamund and Mojave, Kern Co., Apr. 30, 1927, *Abrams 11755* (P, S); head of Kelso Valley, 16 miles south-southwest of Weldon, Kern Co., alt. 1500 m., *Cal. Mus. Vert. Zool.* (C); sand-dunes, halfway from Bakersfield to Tejon Pass, March 19, 1925, *Munz 8999* (C, P); between Willow Springs and Tehachapi, Mohave Desert, June 25, 1908, *Abrams & MacGregor 836* (D, G, NY, S, US); Willow Springs, Kern Co., July 1, 1905, *F. Grinnell 444* (US), July 1, 1905, *F. Grinnell 447* (US); Oak Creek, Kern Co., June 20, 1905, *F. Grinnell 415* (US); rocky alluvial slope, east slope of Walker Pass,

Kern Co., May 13, 1930, alt. 1300 m., *J. T. Howell 4999* (CA); near Acton, May 21, 1893, alt. 900 m., *Hasse* (S); Palmdale, Los Angeles Co., June, 1902, *Elmer 3661* (D, G, MBG, NY, P, S, US, V); Lancaster, Los Angeles Co., May, 1895, *Davidson* (C); Little Rock Creek, Los Angeles Co., May 19, 1921, alt. 1000 m., *Peirson 1086* (S); Mohave, May 20, 1903, *Jones* (P); Antelope Valley, Los Angeles Co., Apr. 19, 1925, *Hoffmann* (SBM); among rocks, Vorlrigger Spring, Goffs, Lanfair Road, San Bernardino Co., Apr. 23, 1928, alt. 1100 m., *Ferris 7254* (NY); Kramer, Mohave Desert, May 1, 1913, alt. 800 m., *Jepson 5329* (G); sandy soil, Argus Mts., Apr.–Sept. 1897, alt. 1500 m., *Purpus* (C, G, MBG, US); Morongo Pass, San Bernardino Co., Apr. 1882, *Parish & Parish 1196* (C, F, G, S); Granite Mts., San Bernardino Co., Apr. 25, 1930, alt. 1000 m., *Hoffmann* (SBM); San Bernardino Range, May, 1893, alt. 800 m., *Hasse* (NY); open desert, southwest of Deadman's Point, Mohave Desert, San Bernardino Co., June 12, 1927, alt. 1000 m., *Howell 2502* (CA); Deadman's Point, May 16, 1920, alt. 1000 m., *Johnston* (P); vicinity of Bonanza King Mine, eastern slope of Providence Mts., Mohave Desert, May 21–24, 1920, alt. 800 m., *Munz, Johnston & Harwood 4026* (C, P, S, US); Pine Tree Ranch, south end of Providence Mts., Mohave Desert, Apr. 13, 1930, *Hilend 383* (UCLA); eastern slope of Providence Mts., May 29, 1861, *Cooper* (G TYPE, US); Barnwell, southeastern Mohave Desert, San Bernardino Co., May, 1911, *K. Brandegee* (C); Hesperia, San Bernardino Co., Apr. 28, 1917, alt. 1000 m., *Spencer 372* (G, P); Coolgardie, Calico Mts., Yucca Mesa, March 27, 1916, *Jepson 6636* (US); desert sand, near Hinckley, Mohave Desert, Apr. 17, 1920, alt. 700 m., *Spencer 372* (NY, P); Pipe Canyon, eastern base of San Bernardino Mts., June 16, 1894, alt. 1500 m., *Parish 2989* (MBG, US); 3 miles east of Warren's Well, Little San Bernardino Mts., May 6, 1922, alt. 1100 m., *Munz & Johnston 5200b* (P); desert side Cajon Pass, May 30, 1918, *Parish 11847* (C); Mohave River, San Bernardino Co., June 1, 1876, *Palmer 420* (C, CA, F, G, MBG, NY), May 31, 1892, *Parish 2438* (F); Victorville, March 25, 1907, *J. Grinnell* (US), May, 1905, *Hall 6194* (C); between Victorville and Mohave, May 24, 1926, *Hart 1* (CA); between Barstow and Victorville, May 14, 1922, *Hart 61* (CA); Victorville, Aug. 8, 1917, *Johnston 1767* (C,

P), July 8, 1917, *Johnston 1769* (C, P), May 16, 1920, *Johnston* (P); Victor, June 25–27, 1888, *Palmer 223½* (NY); Victorville, Apr. 27, 1915, *Parish 9695* (S); southeastern Calif.-Ariz., coll. of 1876, *Palmer* (G TYPE of *L. Cooperi* var. *pubiflora*); Mohave River, southeastern California, coll. of 1876, *Palmer 420* (F, MBG, PA, US); La Puente, Colorado Desert, Apr. 1, 1914, *Parish 9048* (S); 14 miles south of Needles, March 22, 1921, *Harrison, Kearney & Fulton 7530* (MBG, SAC); Shepherd's Canyon, Apr. 30, 1897, alt. 1500 m., *Jones* (P); Salton, Colorado Desert, March 18, 1921, *Jaeger 1159* (P); Eagle Mt., Colorado Desert, Riverside Co., May, 1905, alt. 650 m., *Hall 6031* (C); San Felipe, Apr. 13, 1896, and Apr. 27, 1894, *K. Brandegee* (C); San Felipe Hill, Apr. 19, 1906, alt. 800 m., *Jones* (P).

Gray's variety *pubiflora* cannot be maintained, as flowers taken at random from plants collected in almost any locality show a wide range of variation in respect to the amount of pubescence on the corolla. Also, *L. Shockleyi* must fall to synonymy under *L. Cooperi*. The type, collected at Candelaria, Nevada, has large calyces that have been much expanded by the growing fruit, thus making the nerves very prominent. This condition is unusual, but is apparently a fortuitous or abnormal variation, as, in addition to the above plant, the following collections show this peculiarity, at least to some extent: Walker River, Utah, June 9, 1889, *H. Engelmann* (MBG); Mohave River, San Bernardino Co., California, *Parish 2438* (F); Victorville, San Bernardino Co., *Johnston 1767* (C, P). Jones' plant from Hawthorne, Nevada, Apr. 22, 1907 (P), is unusual in being almost devoid of all pubescence.

The nature of the fruit is sufficient to separate *L. Cooperi* from any other member of the genus in North or South America. In addition, the great amount of pubescence commonly present serves to distinguish it from *L. pallidum*, the species with which it has been most frequently confused.

38. **L. macrodon** Gray, Proc. Amer. Acad. **6**: 45. 1862; Bot. Calif. **1**: 542. 1876, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 238, 437. 1886; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1286. 1924. Pl. 12, figs. 1–3; pl. 13, fig. 1; pl. 18, figs. 19–21.

L. pallidum γ *macrodon* (Gray) Terrac. Malpighia 4:520. 1891.

A much-branched, somewhat spreading, spiny, pubescent shrub 1–3 m. tall; branches rather slender, curved, chalky-gray to reddish, young twigs covered with gray tomentum, spines blunt, 2–5 mm. long; leaves linear-spatulate to narrowly oblong-oblanceolate, 6–30 mm. long, 2–5 mm. wide, acute to rounded at apex, gradually attenuate to a petiole 1–2 mm. long, bright green, minutely but abundantly pubescent; calyx campanulate, pubescent, 6–8 mm. long, the 5 linear lobes about twice the length of the tube, acute, sinuses rounded or truncate; corolla white or pale lilac, tube greenish-white, conspicuously contracted above ovary, 9–12 mm. long, 2.5–3 mm. in diameter at the summit, glabrous without, lobes 5, ovate-triangular, 2–3 mm. long, rotate, their margins slightly revolute and very remotely ciliolate; stamens equalling or exceeding corolla-tube slightly; filaments subequal, adnate about half the length of the corolla-tube, rather densely clothed with long hairs for about 1 mm. above the adnate portion, corolla-tube hairy from free base of filament almost to base of corolla, anthers 1.5 mm. long; style 2–3 mm. shorter than stamens; fruit 2–3-carpellary, each carpel with hardened pericarp, constricted about $^2/_5$ the way from base, with 1 or 2 large seeds in each carpel above constriction, 1–several abortive ovules or incompletely developed seeds in lower half, lower half with less hardened pericarp.

Type: "Fremont Exped. California, 1849." (NY). The type was very probably collected in southern Arizona.

Distribution: southern Arizona, and adjacent Sonora, Mexico.

Material seen:

United States of America

Arizona: no locality indicated, but undoubtedly in southern Arizona, *Fremont Exped. California*, coll. of 1849 (NY type); Arizona, coll. of 1884, *Pringle* (NY); base of Tinajas Altas Mts., March 28, 1930, *Harrison & Kearney 6571* (US); Sacaton, March 19, 1919, *Eastwood 8082* (US), and *8028* (CA), spring of 1908, *Gilman 2408* (US), March 6, 1926, *Loomis 968* (US), March 15, 1930, *Peebles 6455* (P, SAC), Apr. 22, 1930, *Peebles & Kearney 6702* (MBG, P, US); Santa Rosa to Casa Grande, March 13–Apr. 23, 1903, *Griffiths 4031* (US); near Casa Grande, March 20, 1930,

Peebles & Harrison 6461 (US), Feb. 6, 1931, *Peebles 7484* (MBG, P, SAC); Pinal Co., March 5, 1931, *Peebles 7510* (SAC); on flats, near Magma, Pinal Co., Feb. 28, 1930, *Peebles & Loomis 6432* (MBG, P, US); near Gila Crossing, Pima Indian Reservation, Maricopa Co., March 12, 1930, *Peebles 6442* (MBG, P, US); Wellton, Yuma Co., March 2, 1927, *Harrison 3584* (US); about 5 miles east of Wenden, Yuma Co., March 21, 1931, *Harrison, Kearney & Fulton 7525* (P, SAC).

MEXICO

SONORA: vicinity of Navajoa, March 21, 1910, *Rose, Standley & Russell 13157* (NY, US); valley of the Altar River, Caborca, March 24, 1884, *Pringle* (CA, D, F, G, NY, PA, US); vicinity of Hermosillo, March 6, 1910, *Rose, Standley & Russell 12443* (US, but not NY).

Lycium macrodon is very easily recognized by its remarkably long calyx-lobes, the only other North American species having a calyx approaching it being *L. Richii.* The fruit, however, is entirely dissimilar in the two.

39. **L. puberulum** Gray, Proc. Amer. Acad. **6**: 46. 1862, and Syn. Fl. N. Amer. ed. 2, **2**[1]: 238. 1886; Coult. Contr. U. S. Nat. Herb. (Bot. W. Tex.) **2**: 301. 1892; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1286. 1924. Pl. 18, figs. 22–24.

A sparingly branched, spiny shrub 0.7–1.5 m. tall; branches usually slender and flexuous, well armed with slender, needle-like spines 5–10 mm. long, dark grayish-green to olive-purple, glabrous at least in age; leaves 3–6 in a fascicle, broadly elliptic to oblong-obovate, 5–15 mm. long, about ⅓ as broad as long, rounded at apex, sessile or subsessile, densely short-pubescent, not fleshy, midnerve evident; flowers 1–2 in the leaf fascicles, pedicels about 2 mm. long; calyx broadly campanulate, 4–6 mm. long, very densely short-pubescent, somewhat glandular, the 5 lobes oblong-ovate, equal to or twice the length of the calyx-tube, pubescent on both surfaces; corolla tubular-campanulate, "tube white, limb yellowish-green," tubular portion 9–12 mm. long, 1.5 mm. wide at base, about 3 mm. in diameter at top, glabrous without, lobes 5, ovate, $^1/_5$–$^1/_4$ the length of the tube, commonly reflexed, their margins not ciliate; stamens equal to corolla-tube or slightly

shorter, filaments equal or subequal, adnate to the corolla-tube for about ⅔ of its length, glabrate, but the lower ⅔ of the corolla-tube densely hairy, anthers 1 mm. or less long; style equalling filaments or slightly shorter than they, included in corolla-tube; fruit sclerenchymatous, 1 or 2 seeds in each carpel.

Type: El Paso, Texas, *Wright 1609* (G).

Distribution: southern Texas, along the Rio Grande River.

Material seen:

United States of America

Texas: on the Rio Grande River, June 15, 1858, *Hayes* (US); Presidio, March 25, 188–, *Havard,* (US); Texas, *Havard* (F); Presidio, western Texas, March, 1881, *Havard 158, 159* (G, P, S); foothills of Chisos and plains, Aug. 1883, *Havard 91* (US); stony hills on the Rio Grande, between ? and San Eleaganio, Mex. Bound. Surv., *Wright* (NY); El Paso, *Wright 1609* (F, G type, MBG); Indian Hot Springs, Apr. 30, 1930, *Jones 26242* (MBG, P).

Most of the material that has been seen has no fruits; however, in the packet on one of the sheets from the United States National Herbarium (no. 55689), collected by Sutton Hayes, on the Rio Grande River, Texas, June 15, 1858, there are some fruits which presumably belong to the specimen mounted on the sheet. These fruits are two-seeded, with a hardened pericarp, apparently being the same type of fruit as that of *L. macrodon.* Jones' collection has mature fruits and proves that the species is very similar to *L. macrodon* in this character.

As the name suggests, *L. puberulum* is conspicuous because of the dense pubescence on the calyx and leaves; it is simulated in calyx-characters by *L. Cooperi* and *L. Parishii,* but need not be confused with either because of the difference in the fruit characters. In *L. Cooperi* the calyx is much larger than in *L. puberulum* and the tube is longer in proportion to the lobes.

Section II. Selidophora C. L. Hitchcock.

Section Selidophora C. L. Hitchcock, sect. nov.

Carpels many-ovuled. Fruit fleshy, many-seeded. Filaments enlarged and glandular at base, glandular portion with fringe of cilia.

Key to Species

A. Calyx-lobes as long as, or much longer than, calyx-tube; leaves 5–25 mm. broad .... *43. L. ciliatum*

AA. Calyx-lobes usually not longer than calyx-tube; leaves seldom over 5 mm. broad.

B. Corolla pubescent exteriorly near the base.

C. Plants dwarf, spreading, 1–2 dm. tall; corolla-tube 2.5–3.5 mm. long, but little greater in diameter at top than at bottom... *42. L. Vergarae*

CC. Plants 4–25 dm. tall; corolla-tube 3–5 mm. long, 2–3 times as great in diameter at top as at bottom........ *41. L. chilense*

BB. Corolla glabrous exteriorly near the base........ *40. L. Comberi*

40. L. Comberi C. L. Hitchcock, sp. nov.[59]

Pl. 19, figs. 13–15; pl. 24.

A very leafy, heavy, much-branched, spreading shrub 0.5–2 m. tall; branches exceedingly knotty, heavy, and rigid, spines confined to pungent tips of short, thick, lateral branchlets, not sharp, bark silvery when young, dark gray-black, much cracked and furrowed on older branches, the nodes enlarged, very close together (1–3 mm.); leaves 3–9 in a fascicle, linear, 5–20 mm. long, 1 mm. broad, rather thickly beset with very short, stiff, simple or forked hairs; flowers "pale yellow, very sweetly scented," very numerous, 1–2 at a node, on pedicels 5–10 mm. long; calyx campanulate, 3.5–5 mm. long, about 2 mm. in diameter, tube 2–3 times as long as the lobes, nearly glabrous or somewhat puberulent, lobes 5, triangular-acute, their margins densely ciliate; corolla-tube infundibuliform, 4–5 mm. long, about 3 mm. in diameter at summit, 2 mm. or less in diameter at base, glabrous exteriorly, lobes 5, 3–4 mm. long (about ⅔ the length of the corolla-tube), oblong, spreading or reflexed, usually with revolute, ciliate margins; stamens 5, subequal, exserted 2–4 mm. from corolla-tube, filaments nearly equalling corolla-lobes, adnate to

[59] **L. Comberi** C. L. Hitchcock, sp. nov., fruticosum, foliosissimum, ramosissimum, 0.5–2 m. altum; foliis linearibus, 5–20 mm. longis, 1 mm. latis, 3–9-fasciculatis, hispidulosis; floribus numerosis, luteolis, pedicellis 5–10 mm. longis; calyce campanulato, 3.5–5 mm. longo, 2 mm. in diametro, 5-fido, tubo lobis 2–3-plo longiore; corollae tubo infundibuliformi, 4–5 mm. longo, ad verticem 3 mm. in diametro, ad basem 2 mm. vel minore lato, extra glabro, 5-fido, lobis 3–4 mm. longis; staminibus subaequalibus, e corollae tubo 2–3 mm. exsertibus, corollae tubi partem tertiam inferam adhaerentibus, ad basem amplificatibus, glandulosis, fimbriato-glandulosisque; stylo 1–2 mm. staminibus longiore; bacca ignota. Collected at Zapala, Terr. Neuquen, Andes of Argentina, 38° 41′ S, Aug. 11, 1925, *Comber 127* (KEW).

the corolla-tube for about ⅓ its length, glabrous at point of adnation, but enlarged, glandular, and with a fringe of hairs just above this point, adjacent corolla-tube pubescent between filaments, anthers about 1 mm. long; style 1–2 mm. longer than stamens; berry not seen.

Type: Zapala, Terr. Neuquen, Andes of Argentina, 38° 41′ S, Aug. 11, 1925, *Comber 127* (KEW).

Distribution: known only from type locality.

Material seen: only the type specimen has been seen.

This specimen was labelled "L. puberulentum," but it is amply distinct from that species. It is readily distinguished from all other members of the genus by the glandular-based filaments, coupled with the exteriorly glabrous corolla-tube and the shape of the calyx-tube.

41. L. chilense Miers ex Bertero, Merc. Chil. 15: 693. 1829, and Ruschenberger in Amer. Jour. Sci. **23**: 96. 1832, English translation; A. DC. 5me Not. Pl. Rar. Nouv. Jard. Bot. Genève 23. 1833 (Mem. Soc. Phys. & d'Hist. Nat. Genève **6**: 231. 1833); Colla, Mem. Accad. Sci. Tor. (Pl. Rar. Reg. Chil.) **38**: 133, *pl. 44*. 1835 (date from Ind. Lond.); Walp. Rep. Bot. Syst. **3**: 108. 1844; Remy in Gay, Hist. Chil. Bot. **5**: 92. 1849; Dunal in DC. Prodr. **13**^{1}: 514. 1852; Miers, Ann. & Mag. Nat. Hist. II, **14**: 338. 1854, and Ill. S. Amer. Pl. **2**: 131, *pl. 72D*. 1857; Reiche, Anal. Univ. Chil. **123**: 393. 1908, and Fl. Chil. **5**: 313. 1910; Bailey, Cycl. Hort. **4**: 1930. 1916. Pl. 19, figs. 4–6.

L. chilense var. *glaberrimum* Phillippi, Linnaea **33**: 206. 1864.

L. chilense α *normale* Terrac. Malpighia **4**: 528. 1891.

L. chilense α *normale* var. *gracile* (Meyen) Terrac. *l. c.*

L. chilense α *normale* f. *glaberrima* (Philippi) Terrac. *l. c.*

L. chilense β *rachidocladum* var. *capillare* subvar. *filifolium* (Gill.) Terrac. *l. c.* 529.

L. chilense β *rachidocladum* var. *capillare* subvar. *filifolium* forma *minutifolium* (Walp.) Terrac. *l. c.* 530 (should be (Miers) Terrac.).

L. chilense var. *ovatum* Philippi, Anal. Univ. Chil. **91**: 21. 1895.

L. chilense var. *petiolatum* Philippi, *l. c.*

L. chilense var. *tomentosulum* Philippi, *l. c.*

L. chilense var. *glabriuscula* Philippi, *l. c.* 22.

L. chilense subsp. *normale* Reiche, Anal. Univ. Chil. **123**: 393. 1908, and Fl. Chil. **5**: 314. 1910.

L. chilense subsp. *normale* var. *tomentosulum* (Phil.) Reiche, Anal. Univ. Chil. **123**: 394, 1908, and Fl. Chil. **5**: 314. 1910.

L. chilense subsp. *normale* var. *ovatum* (Philippi) Reiche, Anal. Univ. Chil. **123**: 394. 1908, and Fl. Chil. **5**: 314. 1910.

L. chilense subsp. *normale* var. *venosum* (Philippi) Reiche, Anal. Univ. Chil. **123**: 394. 1908, and Fl. Chil. **5**: 314. 1910.

L. chilense subsp. *normale* var. *glaberrima* (Philippi) Reiche, Anal. Univ. Chil. **123**: 394. 1908, and Fl. Chil. **5**: 314. 1910.

L. chilense subsp. *gracile* var. *gracile* Reiche, Anal. Univ. Chil. **123**: 395. 1908, and Fl. Chil. **5**: 315. 1910.

L. chilense subsp. *paraguariense* Hassler in Fedde, Rep. Spec. Nov. **15**: 240. 1918, in part, at least as to *L. gracile* Meyen.

L. chilense var. *normale* Hassler, *l. c.*

L. nutans DC. 5me Not. Pl. Rar. Nouv. Jard. Bot. Genève 24. 1833 (Mem. Soc. Phys. & d'Hist. Nat. Genève **6**: 232. 1833) (herb. name of Poeppig).

L. gracile Meyen, Reise um die Erde **1**: 380. 1834 (footnote); Nees, Nov. Act. Acad. Caes. Leop. **19**, suppl. 1: 389. 1843; Walp. Rep. Bot. Syst. **3**: 108. 1844; Remy in Gay, Hist. Chil. Bot. **5**: 92. 1849; Philippi, Anal. Univ. Chil. **91**: 24. 1895.

L. canum Gill. in Walp. Rep. Bot. Syst. **3**: 112. 1844, nomen.

L. filifolium Gill. ex Miers, Ann. & Mag. Nat. Hist. II, **14**: 336. 1854, and Ill. S. Amer. Pl. **2**: 130, *pl. 72B.* 1857.

L. filifolium var. *minutifolium* Miers, Ann. & Mag. Nat. Hist. II, **14**: 337. 1854, and Ill. S. Amer. Pl. **2**: 130. 1857.

L. patagonicum Miers, Ann. & Mag. Nat. Hist. II, **14**: 340. 1854, and Ill. S. Amer. Pl. **2**: 133, *pl. 72F.* 1857; Speg. Rev. Fac. Agr. y Vet. La Plata (Pl. Patag. Austr.) **3**: 552. 1897.

L. patagonicum α *normale* Terrac. Malpighia **4**: 533. 1891.

L. Grevilleanum Gill. ex Miers, Ann. & Mag. Nat. Hist. II, **14**: 342. 1854, and Ill. S. Amer. Pl. **2**: 135, *pl. 73F.* 1857.

L. scoparium Miers, Ann. & Mag. Nat. Hist. II, **14**: 340. 1854, and Ill. S. Amer. Pl. **2**: 134, *pl. 73A.* 1857; Griseb. Abhandl. König. Ges. Wiss. Gött. (Symb. Fl. Arg.) **24**: 246. 1879.

L. scoparium α *normale* Terrac. Malpighia **4**: 532. 1891.

L. scoparium var. *lineare* Miers, Ann. & Mag. Nat. Hist. II, **14**: 341. 1854, and Ill. S. Amer. Pl. **2**: 134, *pl. 73B*. 1857.

L. scoparium α *normale* lusus *lineare* (Miers) Terrac. *l. c.*

L. scoparium var. *confertifolium* Miers, Ann. & Mag. Nat. Hist. II, **14**: 341. 1854, and Ill. S. Amer. Pl. **2**: 135, *pl. 73C*. 1857.

L. scoparium α *normale* lusus *confertiflorum* (Miers) Terrac. *l. c.* (should be *confertifolium*).

L. scoparium var. *divaricatum* Miers, Ann. & Mag. Nat. Hist. II, **14**: 341. 1854, and Ill. S. Amer. Pl. **2**: 135, *pl. 73D*. 1857.

L. scoparium α *normale* lusus *divaricatum* (Miers) Terrac. *l. c.*

L. scoparium var. *affine* Miers, Ann. & Mag. Nat. Hist. II, **14**: 342. 1854, and Ill. S. Amer. Pl. **2**: 135, *pl. 73E*. 1857.

L. scoparium α *normale* lusus *affine* (Miers) Terrac. *l. c.*

L. scoparium var. *calycinum* Griseb. Abhandl. König. Ges. Wiss. Gött. (Symb. Fl. Arg.) **24**: 246. 1879 (judging from description).

L. scoparium α *normale* lusus *calycinum* (Griseb.) Terrac. *l. c.*

L. scoparium α *normale* lusus *Grevilleanum* (Gill.) Terrac. *l. c.*

L. gelidum Wedd. Chlor. And. **2**: 108. 1857.

L. sessiliflorum Philippi, Anal. Univ. Chil. **91**: 22. 1895 (judging from description).

L. lasiopetalum Speg. Anal. Soc. Cient. Arg. **53**: 170. 1902.

L. pulverulentum Skottsb. Kungl. Svensk. Vetens.-Akad. Handl. (Bot. Ergeb. Schw. Exp. Patag. 1907–9) **56**[5]: 294. 1916.

A somewhat trailing or spreading, sparingly armed or unarmed, pubescent shrub 0.4–2.5 m. tall, pubescence simple or branched; branches usually slender, frequently flexuous, sometimes prostrate, usually grayish, sometimes very dark, pubescent with stellate or forked hairs when young, the spines when present few and not very sharp; leaves in fascicles of 1–6, exceedingly variable, linear to ovate or spatulate, 1–3 cm. long, 0.5–6 (8) mm. broad, sessile or petiolate, acute to rounded, pubescent with multicellular stellate hairs, frequently with simple hairs intermixed, or occasionally with only unbranched hairs; flowers borne singly or in 2's or 3's, on pedicels 2–10 mm. long, pubescent; calyx cup-shaped, usually pubescent with branched hairs, tube 1.5–3 mm. long, lobes 5, short-triangular to linear or spatulate, 1–3 mm. long;

corolla greenish with purple lobes and veins, broadly infundibuliform, tubular portion 3–5 mm. long, 2–3 times as wide at summit as at top of ovary, with pilose band about 1 mm. above base, rest of tube less abundantly pubescent or glabrous, lobes 5, oblong-ovate, about equal in length to tube or somewhat shorter, spreading or slightly reflexed, ciliate, more or less pubescent exteriorly; stamens 5, exserted, filaments equal or subequal, equal to or slightly shorter than corolla-lobes, adnate to near the middle of the corolla-tube, enlarged and glandular at base, the glandular surface fringed with a row of rather long cilia, adjacent corolla-tube with tuft of hairs between stamen bases, anthers 1–1.5 mm. long; style equalling or 1–2 mm. longer than stamens; ovary ovoid, 4–6 mm. long, ⅓–½ as thick, red, many-seeded.

Type: no type specified, but "in sylvaticis montis la Leona, in rupestribus St. Jago, Nov. 1828, *Bertero 396*," which is represented in many of the herbaria of the world may be taken as representative of the species as Bertero understood it.

Distribution: Chile, from Atacama southward to Concepcion, inland to central Argentina and southward to Terr. Santa Cruz, Argentina.

Material seen:

CHILE: without locality, *Gay* (G), *Lechler* (V); coll. of 1829, *Bertero 420* (D); San Antonio, Oct. 1921, *Claude-Joseph 1729* (US); in sylvaticis montis la Leona, in rupestribus St. Jago, Nov. 1828, *Bertero 396* (D, MBG, NY, V); Copiapo, Feb. 1888, *Philippi* (KEW); Prov. Coquimbo, coll. of 1838, *Gay* (MBG photograph of TYPE of *L. gelidum* at Paris); Coquimbo, *E. C. Reed* (KEW); San Felipe, Prov. Aconcagua, Nov. 1923, *Claude-Joseph 2507* (US); Concon, Prov. Valparaiso, *Miers 328* (US); Valparaiso, *Wilkes Expl. Exped.* (US); Valparaiso, coll. of 1832, *Gaudichaud 117* (D); Valparaiso, coll. of 1830, *Bridges* (KEW); prope Valparaiso, coll. of 1831, *Cuming 367* (KEW, V); Pudahuel, Prov. Santiago, *E. C. Reed* (G); Lampa, Prov. Santiago, Nov. 1869, *E. C. Reed* (KEW); Cerro Blanco, vicinity of Santiago, Nov. 16, 1900, *Hastings 169* (C, US); Santiago, sterile hills near city, Sept. 22, 1900, *Hastings 50* (NY); Santiago, Dec. 1922, *Claude-Joseph 2224* (US); Santiago, coll. of 1856–57, *Germain* (KEW, V); San Antonio, Prov. Santiago, Dept. San Antonio, Oct. 16, 1927, alt.

18 m., *Montero 210* (G, MBG); ex saxosis Chilensibus juxta Santiago, Cerro de San Cristobal, May 14, 1882, *J. Ball* (KEW); Cerro S. Cristobal, Santiago, Oct. 7, 1928, alt. 700–800 m., *Looser 773* (G); Prov. Santiago, *E. C. Reed* (KEW); Jahuel, Prov. O'Higgins, Oct. 1927, *Elliott 211* (KEW); prope la Concepcion, Oct. 1825, *Macrae* (D, KEW); Renaca, 6 kilom. al Norte de Viña del mar, Feb. 1911, *Jaffuel 881* (G); in collib. arenis marit. ad Concon, Sept. 1827, *Poeppig 85* (= *238*?) (V).

Argentina: Fenix-Islen, Patagonia, Terr. Santa Cruz, Oct. 12, 1908, *Skottsberg 624* (ST type of *L. pulverulentum*); Zapala, Neuguen, Feb. 1930, *Hauman* (MBG); Santa Cruz, Feb. 1903, *Cardoso* (MBG); Patagonia andina, Dec. 10, 1908, *Skottsberg 624* (ST); Port St. Elena, Patagonia, *Capt. King* (KEW type collection of *L. patagonicum*); Puerto, San Antonio, eastern Patagonia, in areno mobili, Dec. 10, 1904, *Dusén 5239* (ST); Terr. Santa Cruz, Nov. 20, 1928, alt. 200 m., *Donat 147* (MBG); island in Rio Chico, 150 miles west by north of Puerto San Julian, Terr. Santa Cruz, coll. of 1928, *Blake* (KEW); head of Rio Negro, Dec. 1891, *Andrews 36* (KEW); Puerto Madryn, Terr. Chubut, Apr. 1914, *Hauman* (MBG); Valle de Escalante, Terr. Chubut, Dec. 20, 1929, *Ferruglio* (MBG); Camarones, Terr. Chubut, coll. of 1912, *Aurelius 5* (ST); Chubut, Meseta de Espinosa, Nov. 1929, *Ferruglio* (MBG); Patagonia, lat. 50° 30′ S, coll. of 1882, *Moreno & Tonini 528* (NY); Paso Cruz, lat. 34° S, alt. 1600 m., *Kuntze* (US); vicinity of General Roca, Rio Negro, Sept. 1914–Feb. 1915, alt. 250–360 m., *Fischer 17* (F, G, KEW, MBG, NY, US); Loberias de Viedma, Rio Negro, Nov. 15, 1928, *Castellanos* (MBG); Viedma, camino al faro, Rio Negro, Nov. 14, 1928, *Castellanos* (MBG); El. Jafuel, Cordillera de Larioja, March 3, 1879, *Hieronymus & Niederlein* (KEW); San Luis, Chisaca, Dec. 14 & 19, 1925, *Castellanos* (MBG); Nogoli, Feb. 10, 1925, *Castellanos* (MBG); San Francisco, Feb. 12, 1925, *Castellanos* (MBG); Alto del Yeso, mt. range in Prov. San Luiz (bordering Mendoza), *Miers 651* (US type collection of *L. scoparium*); Mendoza, *Philippi* (V); ex regione inferiori Andinum Chilensium, juxta Santa Rosa de los Andes, Prov. Mendoza?, May, 1882, *Ball* (G, KEW, NY); Tupungato, Prov. Mendoza, Dec. 1916, *Ruiz 253* (MBG); Moreno (in puma de Jujuy), in declivibus montis saxo-

sis apricis siccis, Prov. Jujuy, Nov. 11, 1904, alt. 3500 m., *Fries 751* (ST); Rodeo, San Juan, Dec. 20, 1929, *Moreau* (MBG); Copres, Salta, March 3, 1927, *Castellanos* (MBG); Sierras Pampeanus, Feb.–Apr. 1881, *Lorentz* (ST, V); San Francisco, Catamarca, Jan. 31, 1930, *Castellanos* (MBG); Chacra de la Merced, near Cordoba, Oct. 1887, *Hieronymus* (KEW); Curaco, Pampa Central, Jan. 8, 1927, *Castellanos* (MBG); Sierras Pampeanus, coll. of 1887, *Lorentz 109* (US); Quehué por Utracan, Pampa Central, Jan. 7, 1927, *Castellanos* (MBG); Paso Cruz, Jan. 1892, *Kuntze* (NY, US); Cerro Peña, Prov. Jujuy, Feb. 8, 1927, alt. 3000 m., *Venturi 4904* (CA, MBG); Buenos Aires, Bahia Blanca, Oct.–Nov. 1903, *Ameghino* (MBG); Cordoba, Dec. 3, 1902, *Stuckert 12172* (D); Altos Cementerio, Cordoba, Nov. 30, 1897, *Stuckert 4007* (D).

As Miers pointed out, *L. chilense* is typical of a huge aggregate of forms characterized by stellate pubescence, with a pubescent ring near base of the corolla-tube, exteriorly, and with glandular, enlarged filament bases. The group is an extremely variable one, the leaves and pubescence especially showing an unusual amount of variation. In working with the material of this and other closely related "species" the writer combined a number of species and varieties under the one name. The different species that have been described have been set off on leaf characters chiefly,—organs which are too variable in the genus, and in this species in particular, to be of much taxonomic worth. It is possible to trace a gradual series from linear to narrowly oblong leaves in plants from any one locality, and indeed, sometimes on the same plant.

There are certain tendencies within the species, however, that are of interest. The following plants from southern Argentina ("Patagonia") have narrow leaves and smaller flowers than usual, the leaves ranging from 0.5 to 2 mm. broad, and 5 to 20 mm. long, the corollas being from 5 to 9 mm. long, and the calyx 1.5 to 3 mm. long; *L. filifolium* and *L. patagonicum* belong to this group.

Chile: Penaflor Cerro, near Santiago, Oct. 1923, *Montero 74* (G).

Argentina: Carmensa, Prov. Mendoza, Nov. 5, 1928, *Parodi 8583* (G); Renca, San Luis, Nov. 19, 1925, *Castellanos* (MBG);

Cordoba de la Rioja, coll. of 1873, *Lorentz & Hieronymus* (NY); El Jaquel, Cordillera de la Rioja, March 3, 1879, *Hieronymus & Niederlein 345* (D); Bahia Blanca, Prov. Cordoba?, coll. of 1837, *J. Tweedie* (KEW); south of Prov. Buenos Aires, "Patagonia," *J. Tweedie* (KEW); south of Province of Buenos Aires, *J. Tweedie* (KEW TYPE collection of *L. filifolium* var. *minutifolium*); Monte del Loro, pampas of Buenos Aires, *Gillies* (KEW); Bahia Blanca, coast of Patagonia, early in Oct. 1832, *Darwin 509* (KEW TYPE collection of *L. filifolium*); head of Rio Negro, Nov. 1891, *Andrews 17* (KEW); Puerto Madryn, Terr. Chubut, Apr., 1914, *Hauman* (MBG); Travesia de Rawson à la Cordillera, Prov. Chubut, Nov. 1–30, 1903, *Illin 187* (C); Rio Negro, coll. of 1838–42, *Wilkes Expl. Exped.* (G, US); Patagonia, lat. 50° 30′ S, coll. of 1882–84, *Moreno & Tonini 527* (NY); without locality, *Capt. Middleton* (KEW); Pampas, 34° W, Jan. 1892, *Kuntze* (NY, US); Argentine Republic, Sept. 1872, *Jameson* (KEW).

Lycium gracile has leaves much like the preceding group, the leaves being 1.5–2.5 mm. broad, the corolla 6–8 mm. long, and the calyx 1.5–3 mm. long. This group is exemplified by the following collections:

CHILE: Coquimbo, coll. of 1888, *Philippi* (KEW, US); Iter Mendocinum, Cordillera de Chile, coll. of 1868–69, *Philippi* (D); Atacama, Sept.–Oct. 1890, *Morong 1116* (F, MBG, NY, PA, US); Copiapo, Prov. Atacama, Quebrada de Chauchoquin, Sept. 1885, *Gigoux* (G); vicinity of Copiapo, coll. of 1922, *Gigoux* (G); vicinity of Copiapo, Nov. 16, 1925, alt. 370 m., *Johnston 4989* (G).

ARGENTINA: Andes, 38° 41′ S, Aug. 24, 1925, alt. 250–300 m., *Comber 28* (KEW).

The type of *L. scoparium* is very much like that of *L. chilense*, but some of Miers' varieties under the former species have leaves 3–7 mm. broad; in this group the pubescence is very frequently unbranched. The following collections are of this nature:

CHILE: Valparaiso, Fesen in der Nähe des Meeres, Dec. 15, 1895, *Buchtien* (ST, US); Valparaiso, coll. of 1856–57, *Germain* (D, KEW); Punta, March, 1923, *Claude-Joseph 2149* (US); Santiago, coll. of 1888, *Philippi* (US); Santiago, *Philippi 583* (D); Limache (Quinta Garaventa), *Looser 968* (G); Prov. Aconcagua, *Philippi* (V).

ARGENTINA: Mendoza, *Gillies* (KEW TYPE collection of *L. scoparium* var. *affine*); Puente del Inca, Prov. Mendoza, Jan. 1908, *Hauman*, and Feb. 1926, *Yepes* (MBG); Puenta del Inca, in viciniis montis Aconcagua, Prov. Mendoza, March 3, 1903, *Malme 2873* (ST); Santa Rosa de Los Andes to Uspallata, Prov. Mendoza, June 1876, *Moseley* (KEW); Prov. Mendoza, *Gillies* (KEW TYPE collection of *L. scoparium* var. *confertifolium*); Arroyo Frias, prope Rosario, Prov. Santa Fe, Oct. 6, 1929, *Cabrera 920* (G); hedges near Sachal, Prov. San Juan, Sept. 1871 and 1872, *Jameson* (KEW, V); Cordoba, Oct. 18, 1870, *Hieronymus* (NY); bei Cacapiohe in der Nähe der Mina Argentina, Prov. Cordoba, Dept. las Minas, March 19–20, 1877, *Hieronymus* (F); Cordoba, Nov. 1875, *Hieronymus* (KEW); Cordoba, Nov. 1875, *Hieronymus 494* (F, US); Cordoba, Barrancas, coll. of 1875–76, *Hieronymus* (F, US); San Javier, Prov. Cordoba, Dec. 1922, *Hauman* (MBG); Tucuman, *J. Tweedie* (KEW TYPE collection of *L. Grevilleanum*); Campana, Buenos Aires, Oct. 27, 1928, *Parodi 8601* (G).

Lycium chilense can readily be told from *L. ciliatum* because of the narrower, entire leaves, and the much shorter calyx-lobes.

42. L. Vergarae Philippi, Anal. Mus. Nac. Chil. Bot. (Cat. Pl. Itin. Tarapaca) 8: 67. 1891; I. M. Johnst. Physis **9**: 319. 1929.
Pl. 19, figs. 16–18.

L. chilense subsp. *normale* var. *Vergarae* (Philippi) Reiche, Anal. Univ. Chil. **123**: 394. 1908, and Fl. Chil. **5**: 314. 1910.

A much-branched, spreading, prostrate or ascending, armed, pubescent shrub 1–2 dm. tall, pubescence short, somewhat hirtellous and branched; branches slender, armed only with pungent tips of slender branchlets, tan, striate; leaves 3–7 in a fascicle, linear to narrowly oblong-ovate, 4–10 mm. long, 1–2 mm. broad, rounded or acute, tapering to a petiole-like base, densely pubescent; flowers few, borne singly at the nodes, the pedicels 2–4 mm. long; calyx campanulate, 2.5–4 mm. long, densely pubescent, lobes 5, oblong-triangular, nearly or quite equal to tube; corolla greenish yellow, tubular portion broadly tubular-infundibuliform, 2.5–3.5 mm. long, 2 mm. in diameter at the base, but little more at the summit, rather thickly pubescent exteriorly, with a

dense ring of pubescence about 1 mm. above the base, lobes 5, oblong-ovate, spreading, 3–4 mm. long, their margins and outer surfaces thickly beset with branched hairs; stamens exserted 2–3 mm., filaments subequal, adnate for about half the length of the corolla-tube or slightly above, enlarged and glandular at the base of the free portion, its margins densely ciliate with long, much-branched, interlacing hairs, adjacent corolla-tube with a tuft of pubescence between the stamen bases; style somewhat longer than stamens, usually equal to or slightly longer than corolla-lobes; berry ovoid, 5–6 mm. in thickness, red when ripe, many-seeded.

Type: Calalaste, Terr. Los Andes, Argentina, alt. 3700 m., *Philippi* (Museo Nacional, Santiago, Chile).

Distribution: Terr. of Los Andes, Argentina, and adjacent Chile, apparently growing at rather high altitudes.

Material seen:

Argentina: vicinity of Baños San Crispin, about lat. 29° 11′ S, long. 69° 44′ W, Jan. 10–12, 1926, alt. 3300 m., *Johnston 6121* (G).

Chile:

Tarapacá: N. Chile, Feb. 1888, *Philippi* (KEW), probably type collection, in which case, the locality is more apt to be Argentina.

Lycium Vergarae is much like *L. chilense* in most respects and may be but a dwarf variety of that species; however, since it differs in its dwarf, spreading habit, shorter, more tubular corolla, and more densely hairy stamens, the writer believes it specifically distinct.

43. **L. ciliatum** Schlecht. Linnaea **7**: 69. 1832; Walp. Rep. Bot. Syst. **3**: 107. 1844; Mart. Fl. Bras. **10**: 153. 1846; Dunal in DC. Prodr. **13**^{1}: 508. 1852; Griseb. Abhandl. König. Ges. Wiss. Gött. **19**: 216. 1874 (Pl. Lorent. 168. 1874), and **24**: 246 (Symb. Fl. Arg.). 1879. Pl. 19, figs. 7–9.

L. floribundum γ *ciliatum* (Schlecht.) Terrac. Malpighia **4**: 532. 1891.

L. floribundum γ *ciliatum* var. *Grisebachii* Terrac. *l. c.*

L. erosum Miers, Ann. & Mag. Nat. Hist. II, **14**: 343. 1854, and Ill. S. Amer. Pl. **2**: 136, *pl. 74A*. 1857.

L. argentinum Hieron. Bol. Acad. Cienc. Cord. **2**: 39, *pl. 2, figs. 9–11.* 1876.

L. scoparium var. *argentinum* (Hieron.) Griseb. *l. c.*

L. scoparium β argentinum (Hieron.) Terrac. *l. c.* 533.

L. venosum Philippi, Anal. Univ. Chil. **91**: 22. 1895, judging from description.

Salpichroa ciliata Miers, Hook. Lond. Jour. Bot. **4**: 329. 1845; Ann. & Mag. Nat. Hist. II, **14**: 345. 1854, and Ill. S. Amer. Pl. **2**: 138. 1857.

A rather sparingly branched shrub 1–2.5 m. tall; branches slender, somewhat flexuous, hirtellous or, less commonly, puberulent or glabrate, straw-colored; leaves rather broadly ovate to lanceolate, nearly glabrous, or with few simple or forked, stiff, short hairs, blade usually somewhat rounded, 1.5–4 cm. long, 0.5–2.5 cm. broad, margins remotely denticulate or nearly entire (3-lobed in one specimen), usually ciliate, borne singly at the nodes, with petiole 1–3 mm. long; flowers 1–4 at the nodes, pedicels 3–20 mm. long, commonly rather densely glandular-ciliate; calyx campanulate, hirsutulous, tubular portion about 2 mm. long and as much in diameter, lobes 5, linear-lanceolate, much acuminate, 2–6 mm. long, frequently increasing in length with growth of ovary; corolla-tube campanulate, 3–4 mm. long, about 3 mm. in diameter at top, rather densely hairy on the outer surface, about 1 mm. above the base, lobes 5, oblong-oval, spreading, 5 mm. long and half as broad, pubescent on exterior surface, ciliate; stamens 5, subequal, about equalling corolla-lobes, thus much exserted when lobes are spreading, filaments adnate about ⅓ the length of the corolla-tube, with enlarged, glandular, fringed base, corolla-tube with tuft of hairs between filament bases, anthers 1.25 mm. long; style equalling or exceeding stamens 1 or 2 mm.; berry red, ovoid, 5–6 mm. long, 20–60-seeded.

Type: "in Brasilia meridionali ad fluvium Rio Negro," *Sellow* (Berlin).

Distribution: central and northern Argentina, from Buenos Aires northward to Bolivia.

Material seen:

BRAZIL: without locality, *Sellow d1012* (G photograph of TYPE); without locality, *Sellow* (KEW, probably TYPE collection).

Bolivia: Cochabamba, March, 1892, alt. 800 m., *Kuntze* (F, NY).

Argentina: without locality, June 1906, *Gandoger* (MBG); Ambil, Apr. 4, 1908, *Stuckert 18781* (D); Los Hornillos, Prov. Rioja, March 8, 1879, *Hieronymus & Niederlein 179* (D); Quinta, pr. Laguna de la Brea in solo salso in dumetris, June 13, 1901, *Fries 173* (ST); Salta, Oct. 1892, *Kuntze* (NY); Salta, Nov. 1891, *Kuntze* (US); Tres Porteñas, Mendoza, Feb. 10, 1918, *Ruiz* (MBG); El Puesto, Catamarca, Jan. 23, 1930, *Castellanos* (MBG); Tucuman, coll. of 1836, *J. Tweedie* (KEW type collection of *L. erosum*); Barranca colorado, Prov. Tucuman, Sept. 19, 1920, *Venturi* (MBG); Prov. Tucuman, Dept. Capital, Sept. 19, 1920, *Venturi 903* (US); Tapia, Tucuman, Dec. 18, 1911, *Rodriguez 550* (MBG); Chañar Pozo, Tucuman, Aug. 1919, *Venturi 352* (MBG); Prov. Tucuman, Dept. Capital, Feb. 20, 1922, *Venturi 1681* (G, MBG); circa Capia, Prov. Tucuman, Dec. 1902, *Baer 111* (D); Pilcias, Prov. Catamarca, Oct. 1877, *Schickendantz 224* (D); Prov. Catamarca, Dept. Andalgala, Feb. 9, 1915, *Jörgensen 971* (C, G, MBG, US); Tintina, Santiago del Estero, March 8, 1917, *Hauman* (MBG); "El Charco," Prov. Santiago del Estero, Dept. Griminez, March 11, 1930, alt. 300 m., *Venturi 10407* (MBG, ST); Los Cocos, Capilla del Monte, Cordoba, Jan. 26, 1922, *Castellanos* (MBG); Cordoba, Dec. 22, 1876, *Hieronymus 113* (F, US); Salinas Grandes, Prov. Cordoba, Jan. 1916, *Hauman* (MBG); Cordoba, pr. urbem, Oct. 18, 1870, *Hieronymus* (D, NY); Cordoba, en la cercania de la ciudad, Oct. 18, 1870, *Hieronymus* (NY); Cordoba, Nov. 17, 1896, *Stuckert 109* (D); Cordoba, Sept.–Nov. 1876, *Hieronymus* (F); Puerto del Paraiso, Prov. Cordoba, Jan. 13, 1897, *Stuckert 1405* (D); Rio I, Cordoba, Feb. 25, 1897, *Stuckert 2224* (D); Cordoba, pr. urbem, Oct. 18, 1880, *Hieronymus* (KEW type collection of *L. argentinum*); Sierra de Cordoba, Nov. 3, 1899, *Stuckert 7500* (D); Cordoba, Dec. 1891, *Kuntze* (F, NY, US); Altos Seco, Cordoba, Apr. 1898, *Stuckert 4513* (D); Prov. Cordoba, Dec. 24, *Lossen 304* (G, MBG); Cordoba, Nov. 1877, *Lorentz & Grisebach* (KEW); Cordoba, en las Quintas, Oct. 1883, *Galander* (NY); parks, gardens, and environs of city of Buenos Aires, June, 1913, *H. M. Curran 103* (US, in part); Rio Grande, Prov. Cordoba, coll. of 1837, *J. Tweedie* (KEW); Banda

Oriental, Prov. Cordoba?, coll. of 1837, *J. Tweedie* (KEW); Prov. San Luis, Nov. 14, 1925, *Castellanos* (MBG); Renca, Nov. 19, 1925, *Castellanos* (MBG), and Quebrada del Rio de Quines, Feb. 16, 1925, *Castellanos* (MBG).

Miers apparently had not seen the type of *L. ciliatum*, nor did he realize the true nature of the plant when he transferred the species to *Salpichroa*. The characters which he used to show that the species did not belong to *Lycium* are, in reality, all common to that genus. In the same sentence he said "calyx split to the base into distinct, linear segments," and "berry encircled by the longer, enlarged calyx." In actuality, as shown in pl. 19, fig. 7, the calyx is not split to the base, but has a tube about 2 mm. long,—much the same as in *L. puberulum* and similar species. Due to the fact that he had a misconception of the plant, Miers described his *L. erosum* which is identical with *L. ciliatum*.

Lycium argentinum is well within the range of variation of *L. ciliatum*, and cannot be maintained, even as a variety. *Lycium venosum* is referred to this species with some hesitancy, since the type or any other material which can be regarded as authentic for the species has not been seen; however, the description makes it appear almost certain that Philippi had a plant which was the same as Schlechtendahl's *L. ciliatum*.

Section III. SCLEROCARPELLUM C. L. Hitchcock

Section SCLEROCARPELLUM C. L. Hitchcock, sect. nov.

Fruit of two 1-seeded carpels, pericarp much hardened. Filaments not enlarged and glandular at base.

KEY TO SPECIES

A. North American species; lobes of corolla nearly equal to tube. .... *45. L. californicum*

AA. South American species; lobes of corolla $^1/_6$–$^1/_3$ the length of the tube. .... *44. L. Ameghinoi*

44. L. Ameghinoi Speg. Rev. Fac. Agr. y Vet. La Plata (Pl. Patag. Austr.) **3**: 553. 1897. Pl. 18, figs. 16–18.

Grabowskia Ameghinoi Speg. Anal. Soc. Cient. Arg. (Nov. Add. Fl. Patag.) **53**: 168. 1902.

L. durispina Dusén, Svensk. Exped. Magell. **3**^{5}: 251, *pl. 9, fig. 3, pl. 12, fig. 2.* 1900.

A heavy, rigid, spreading shrub; branches and branchlets thick, stout, ending in blunt spines, yellow-gray to dark gray, puberulent when very young, much corrugated and glabrous with age; leaves spatulate or oblanceolate, fleshy, terete or flattened, 3–10 mm. long, 1–1.5 mm. broad, glabrous or very minutely pubescent, 1–6 in a fascicle, from rather conspicuously swollen nodes, these very closely approximated (1–4 mm. apart); flowers 1–4 in a fascicle, on glabrous pedicels 1–2 mm. long; calyx tubular, 3–3.5 mm. long, about 2 mm. in diameter, glabrous or with few hairs on the margins of the lobes, lobes 4, very short, not over ¼ length of tube; corolla tubular, the tube 5–6 mm. long, 2 mm. in diameter at summit, glabrous without, lobes 4, recurved, rounded-cuneate, about 1 mm. long; stamens 4, slightly exserted from tube, filaments unequal, longest about equalling corolla-tube, adnate about ⅓ the length of the corolla-tube, pilose for 1 mm. above the adnate portion, corolla-tube somewhat pubescent immediately below this point; style approximately equalling stamens, or shorter; fruit of 2 carpels with much-hardened pericarp, one large seed in each carpel.

Type: in valleculis siccis glareosis prope Golfo de San Jorge, Feb. 1896, *Sr. Carlos Ameghino* (Spegazzini Herbarium).

Distribution: southern Argentina, from Terr. Rio Negro to Terr. Santa Cruz.

Material seen:

Argentina: Terr. Santa Cruz, Nov. 19, 1928, alt. 250 m., *Donat 37* (MBG); Terr. Chubut, Meseta de Espinoza, Nov. 1929, *Ferruglio* (MBG); Rio Corcovado, Chubut, Feb. 1903, *Illin* (MBG); Camarones, Patagonia, Terr. Chubut, coll. of 1912, *Aurelius*, in part (ST); Peninsula Valdez, playa punta norte, July 20, 1912, *Exp. Roveretto* (MBG); Travesia de Rawson à la Cordillera Argentina, Terr. Chubut, Nov. 1–30, 1903, *Illin 73* (C); vicinity of General Roca, Terr. Rio Negro, Oct. 1914–Feb. 1915, alt. 250–360 m., *Fischer 132* (MBG); alrededores de Valcheta, Terr. Rio Negro, Nov. 22, 1928, *Castellanos* (MBG).

Spegazzini transferred his species to *Grabowskia*, because of the fruit characters. However, it, as well as *L. californicum*, is much more like the other species of *Lycium* in all respects except the nature of the fruit, and, as shown in the discussion under "Mor-

phology," even the type of fruit is more closely approached by *L. macrodon* than by any species of *Grabowskia*.

45. **L. californicum** Nutt. ex Gray, Bot. Calif. **1**: 542. 1876, and Syn. Fl. N. Amer. ed. 2, 2^1: 238, 437. 1886; Abrams, Fl. Los Angeles & Vic. 323. 1917; David. & Moxl. Fl. S. Calif. 321. 1923; I. M. Johnst. Proc. Calif. Acad. Sci. IV, **12**: 1155. 1924; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1288. 1924; Jepson, Man. Fl. Pl. Calif. 890. 1925.

Pl. 12, figs. 4–6; pl. 13, figs. 11–15; pl. 19, figs. 1–3.

L. carolinianum γ *californicum* Terrac. Malpighia **4**: 518. 1891.

L. californicum var. *arizonicum* Gray, Syn. Fl. N. Amer. ed. 2, 2^1: 437. 1886.

L. carolinianum γ *californicum* var. *arizonicum* (Gray) Terrac. *l. c.* 519.

L. carinatum Wats. Proc. Amer. Acad. **24**: 65. 1889; Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1287. 1924.

A densely branched, knotty, decumbent or spreading shrub 0.3–1.5 m. tall; branches very much intertwined, branchlets usually tipped with short, blunt spines, otherwise unarmed, bark yellowish to gray, glabrous to very minutely puberulent or sparsely scurfy; leaves linear-terete, ovoid, or spatuloid, succulent, 2–12 mm. (usually about 5) long, 1–3 mm. broad, sessile or with very short petiole, 1–3 in a fascicle, glabrous or somewhat pubescent; flowers borne singly, pedicels 1–4 mm. long; calyx campanulate, approximately 2.5 mm. long, ½ as great in diameter, usually 2–4-lobed, occasionally 5-lobed, lobes triangular, about ⅓ as long as the tube, usually ciliolate, rest of calyx puberulent; corolla white to light purple, tube 2–3 mm. long, about 2 mm. in diameter, lobes 4, oblong-ovate, about equal to tube, spreading or reflexed, remotely ciliolate; stamens 4, scarcely equalling the corolla-lobes, but exserted, filaments about equal, adnate to slightly above the middle of the corolla-tube, their free base and adjacent corolla-tube densely hairy, but no pubescence below free portion, anthers less than 1 mm. long; style usually exceeding corolla by 1–2 mm.; fruit ovoid, 2–4 mm. long, pericarp much hardened, carpels separating rather readily at maturity, each carpel 1-seeded.

Type: San Diego, U. California, *Nuttall* (G).

Distribution: western Arizona and southern California, mainly along the coast, southward along the coast of Baja California, and at Guaymas, Sonora, Mexico.

Material seen:

United States of America

Arizona: Lowell, Cochise Co., May, 1884, *W. F. Parish 179* (G, US); near Sierra Estrella, Pinal Co., Feb. 25, 1927, *Peebles & Harrison 3546* (US); Santa Cruz Wash, near Casa Grande, Pinal Co., March 24, 1931, *Peebles & King 7508* (SAC); Santa Cruz Wash, Casa Grande, Feb. 17, 1931, *Peebles 7489* (SAC); Maricopa, May, 1885, *A. Gray*, type of *L. californicum* var. *arizonicum* (G); near Casa Grande, March 20, 1930, *Peebles & Harrison 6464* (US); Santa Cruz Wash, near Casa Grande, Feb. 24, 1931, *Peebles & King 7509* (P, SAC); near Casa Grande River, Dec. 24, 1900, *Griffiths 2216* (NY); Santa Rosa to Casa Grande, March 13–Apr. 23, 1903, *Griffiths 4052* (US); near Sacaton, Feb. 10, 1926, *H. F. Loomis 698* (US).

California: San Bernardino, May, 1882, *Lemmon* (C, D); Los Angeles, coll. of 1880, *Nevin* (G); seaside, Santa Monica, March, 1881, *Parry 216* (G, MBG, NY); San Pedro, June 2, 1906, *Eastwood 163* (CA); San Pedro Hills, near Rocky Point, March 14, 1903, *Abrams 3131* (D, F, G, MBG, NY, P, PA, S, US); Pt. Firmin, San Pedro, Apr. 24, 1912, alt. 60 m., *H. H. Smith 4825* (F); Long Beach, Apr. 29, 1887, *B. H. Smith* (PA); borders of salt marshes, Wilmington, March 31, 1882, *Pringle* (CA, F, G, PA, US); Orange Co., fall of 1902, *Geis* (S); Balboa, mainland, near bridge, Feb. 10, 1924, *Peirson 4526* (S); Laguna Beach, fall of 1902, *Geis 581* (P, S); Laguna Beach, May 5, 1918, *Johnston 1949* (C, P); Laguna Beach, clay bluffs near shore, May 5, 1916, *Crawford* (P); shore bluffs, Laguna, July 24, 1916, *Crawford 741* (C, P); Laguna, bluffs overhanging sea, May 5, 1918, *Munz 2196* (P); Catalina Is., March, 1900, *Trask 499* (F); Santa Catalina Is., Jan. 21, 1920, *Millspaugh 4612* (F); Avalon, Santa Catalina Is., March, 1896, *Trask* (MBG); Avalon, Santa Catalina Is., March, 1900, *Trask* (NY); Isthmus, Santa Catalina Is., Apr. 21–26, 1904, *Grant & Wheeler H2447* (S); Isthmus, Santa Catalina Is., *Knopf 419* (F); The Isthmus, Santa Catalina Is., June 10, 1918, *Mrs. C.*

E. Miller (CA); Isthmus Cove, Santa Catalina Is., March 14, 1920, *Millspaugh 4778* (F); Isthmus, Santa Catalina Is., May 23, 1829, *L. W. Nuttall 258*, surely wrong date (F); Pacific slope of Salta Verde, Santa Catalina Is., *Knopf 332* (F); San Clemente Is., March 25, 1918, *Evermann* (CA); San Clemente Is., in heavy soil, Apr. 9, 1923, *Munz 6648* (P); San Clemente Is., Oct. 1902, *Trask 27* (US); San Nicholas Is., Apr. 1897, *Trask* (CA, MBG, US); arroyo cliffs, San Nicholas Is., May, 1901, *Trask 60* (G); La Jolla, San Diego Co., Nov. 24, 1919, *Millspaugh 4450* (F); La Jolla, Nov. 6, 1894, *Snyder* (F); La Jolla, prope San Diego, July, 1919, *Spencer* (MBG); San Diego Co., March 26, 1921, *M. L. Campbell 136* (CA); La Costa, Apr. 1896, *Alderson 1190* (S); river-bank, Del Mar, March 24, 1895, *Angier 14* (MBG); in beach sand, Ocean Beach, San Diego Co., Feb. 28, 1917, *Spencer 266* (G, NY, P); San Diego, June 5, 1895, *Alderson 1001* (S); San Diego, Sept. 3, 1904, *Berg* (C); San Diego, Apr. 4, 1903, *T. S. Brandegee* (C); San Diego, coll. of 1875, *Cleveland* (G); San Diego, Sept. 1878, *Cleveland* (MBG); San Diego, coll. of 1882, *Cleveland* (S); San Diego, May, 1884, *Cleveland* (C); San Diego, July, 1902, *Herre* (S); San Diego, Aug. 8, 1902, *Herre* (P, S); San Diego, March 9, 1882, *Jones 3045* (CA, NY, P, US in part); San Diego, U. Cal., *T. Nuttall* (G TYPE); San Diego, Feb. 28, 1884, *Orcutt* (MBG); San Diego, coll. of 1875, *Palmer 262* (F, MBG, NY); plains south of San Diego, Nov. 3, 1880, *G. Engelmann* (MBG); canyon, Balboa Park, San Diego, Apr. 29, 1924, *Spencer 2394* (G); on slope of clay hill, San Diego, March 13, 1862, *Cooper 468* (G, US); Point Loma, San Diego Co., Feb. 5, 1894, *Sheldon 38* (US); San Diego Coast, Apr. 1903, *Hall 3959* (C); seashore, San Diego, Dec. 1896, *Setchell* (C); Oceanside, San Diego, Apr. 1893, *King* (C); North Coronado, San Diego Co., Apr. 7, 1913, *Eastwood* (CA); Coronado Beach, Apr. 7, 1902, *Grant* (S); North Island, Spanish Bight shore, San Diego, Dec. 27, 1908, *Dudley* (S); south part of San Diego Co., coll. of 1875, *Palmer* (G); Monument, Mexican Boundary, Oct. 10, 1875, *Palmer 146* (C, US).

MEXICO

BAJA CALIFORNIA: ranch, 29 miles southwest of Tia Juana, Apr. 13, 1925, *Jones* (P); Todos Santos Island, March–June, 1897, *Anthony 211* (C, G, MBG, S, US); Guadalupe Is., coll. of 1875,

Palmer 63 (G, MBG, NY, PA); Abreojos Point, March 16, 1911, *Rose 16253* (US); Natividad Is., Apr. 10, 1897, *T. S. Brandegee* (C); mainland near Ascension Island, Apr. 4, 1897, *T. S. Brandegee* (C); Playa Maria, Aug. 23, 1896, *Anthony 146* (C); San Benito Is., March 27, 1897, *T. S. Brandegee* (P); San Benito Is., March 28, 1897, *T. S. Brandegee* (C); San Benito Is., coll. of 1889, *Palmer 916* (G, US); San Benito Is., March 9, 1911, *Rose 16057* (NY, US); San Benito Is., March 9, 1911, *Rose 16065* (US); San Benito Is., March 9, 1911, *Rose 16076* (NY, US).

Sonora: Guaymas, coll. of 1887, *Palmer 178*, type collection of *L. carinatum* (G type, C, NY, US, "L. Angeles Bay" is also written on the US sheet).

Without Locality: *Parry*, coll. of 1882 (MBG).

Lycium carinatum and the variety *arizonicum* cannot be maintained as they are identical with coastal material of *L. californicum*. The second number which Gray cited under *L. californicum* var. *arizonicum*, from Lowell, Arizona, collected by Parish, has leaves 6 mm. long and 2 mm. broad,—even the leaves of the type, which are not over 3 mm. long, are not unusual for either Arizona or coastal plants.

Doubtful and Excluded Species

Lycium acnistoides Griseb. Cat. Pl. Cub. 188. 1866 = Acnistus sp.? The material seen, Cuba, *Wright 3033* (G type, MBG), apparently has induplicate aestivation, and is otherwise more similar to *Acnistus* than to *Lycium*.

L. aggregatum Ruiz & Pavon, Fl. Peruv. **2**: 45, *pl. 182, fig. a.* 1799 = Acnistus aggregatus (Ruiz & Pavon) Miers, Hook. Lond. Jour. Bot. **4**: 341. 1845 = Dunalia campanulata (Lam.) Macbride, Field Mus. Pub. Bot. 8^2: 107. 1930.

L. americanum Jacq. Stirp. Amer. Hist. 65. 1788. Identity uncertain; the original description gives the corolla-length as "pollicaris," a length much in excess of that of any species of *Lycium* seen from the West Indies.

L. arborescens Sprengel, Syst. Veg. **1**: 701. 1825 = Acnistus aggregatus (Ruiz & Pavon) Miers. The description of the plant is very meagre, but shows plainly that the species belongs to *Acnistus* rather than to *Lycium*.

L. boerhaviaefolium Linn. f. Suppl. 150. 1781 = Grabowskia boerhaviaefolia Schlecht. Linnaea **7**: 72. 1832; Lindley, Bot. Reg. **23**: 1985. 1837.

L. brachyanthum Gray ex Hemsl. Biol. Cent.-Am. Bot. **2**: 426. 1882 = Citharexylum brachyanthum Gray, Syn. Fl. N. Amer. ed. 2, **2**[1]: 458. 1886. Pl. 13, figs. 7–10; pl. 19, figs. 22–24.

L. brevipes Benth. Bot. Voy. Sulph. 40. 1844. Identity uncertain, very probably the same as *L. Richii* Gray, but evidence does not warrant an unqualified reduction. See discussion under *L. Richii*.

L. capillare Miers, Ann. & Mag. Nat. Hist. II, **14**: 188. 1854, and Ill. S. Amer. Pl. **2**: 123, *pl. 70E*. 1857. Although no material has been seen which could be referred to this species, the writer feels that it is very probably a valid species.

L. capsulare Linn. Cent. Pl. **2**: 11. 1756; Amoen. Acad. **4**: 308. 1759 = Hydrolea elegans A. W. Benn. Jour. Linn. Soc. Bot. **11**: 271. 1871. Linnaeus' description is not adequate to base a conclusion as to the true status of this species, but it seems certain that it is not a *Lycium*.

L. Chanar Philippi, Anal. Mus. Nac. Chil. Bot. (Cat. Pl. Itin. Tarapaca) 8: 68. 1891 = L. crassispina Philippi, according to Reiche, Fl. Chil. **5**: 317. 1910. However, the original description gives the length of the corolla as 5.5–6 mm., which would preclude such a possibility. Identity uncertain.

L. cornifolium HBK. Nov. Gen. et Sp. Pl. **3**: 54. 1818 = Iochroma cornifolia (HBK.) Miers, Hook. Lond. Jour. Bot. **7**: 347. 1848.

L. floribundum HBK. Nov. Gen. et Sp. Pl. **3**: 51. 1818 = Acnistus, probably Ac. arborescens Schlecht. Linnaea **7**: 67. 1832.

L. fuchsioides Dunal in DC. Prodr. **13**[1]: 603. 1852 = Cestrum aurantiacum Lindley, Bot. Reg. II, **7**: misc. 71. 1844.

L. fuchsioides Humb. & Bonpl. Pl. Aequin. **1**: 147, *pl. 42*. 1808; Hook. Bot. Mag. III, **1**: 4149. 1845 = Iochroma fuchsioides (Humb. & Bonpl.) Miers, Hook. Lond. Jour. Bot. **7**: 345. 1848.

L. geniculatum Fernald, Proc. Amer. Acad. **35**: 566. 1900 = **Grabowskia geniculata** (Fernald) C. L. Hitchcock, comb. nov.

Pl. 13, figs. 2–5; pl. 19, figs. 19–21.

"Branches slender," flexuous, "geniculate," armed with slender

spines 1–1.5 cm. long, 1–2 cm. apart; branches pale yellow to reddish-gray, glabrous; leaf-blades ovate to ovate-oblong, 1.5–2.5 cm. long, 0.8–2 cm. broad, glabrous, glaucous, apex rounded to acute, base narrowed to a petiole 5–10 mm. long, leaves borne on small lateral branchlets, or congested at the nodes, but not truly fascicled; "flowers abundant in small cymes, terminating the rather crowded short ultimate branches," borne on pedicels about 1 cm. long; calyx very broadly campanulate, 2 mm. long, with 5 short subulate lobes about 1 mm. long; corolla obconic, glabrous without, 1.3 cm. long, the 5 lobes ovate, about $^2/_5$ as long as tube; stamens 5, subequal, slightly longer than corolla-lobes, adnate for about 1.5 mm. from base of corolla-tube, filaments hairy to top of tube, adjacent corolla-tube also hairy, anthers about 1.5 mm. long and half as broad; style equalling stamens, stigma flat, round, slightly 2-lobed; ovary 4-celled, 4-ovuled; fruit 2-lobed, ovoid, 6–8 mm. thick, blue, glaucous, 2-carpellary, each carpel 2-celled, with one seed in each cell.

Type: near Tehuacan, Puebla, Mexico, Nov. 22, 1895, *C. G. Pringle 7000* (G).

The large, non-fascicled leaves, the cymose inflorescence, and the 2-carpellary, 4-ovuled fruit place this plant definitely in the genus *Grabowskia* rather than in *Lycium*. This is apparently the first collection of *Grabowskia* in Mexico, the genus being primarily a South American one.

L. gesnerioides HBK. Nov. Gen. et Sp. Pl. **3**: 53. 1818 = Iochroma gesnerioides (HBK.) Miers, Hook. Lond. Jour. Bot. **7**: 346. 1848.

L. glaucum Philippi, Fl. Atac. 43. 1860 = Grabowskia glauca (Phil.) I. M. Johnst. Contr. Gray Herb. **85**: 112. 1929.

L. graciliflorum U. Dammer, Meded. Rijks Herb. Leid. 29: 23. 1916. Identity uncertain, but judging from the original description and a photograph of the type collection at Berlin (G), the species is very close to *L. Morongii* Britton.

L. grandifolium Willd. ex Roem. & Schult. Syst. Veg. **4**: 698. 1819, is surely an Acnistus, and possibly conspecific with *Ac. grandiflorus* Miers, Hook. Lond. Jour. Bot. **4**: 344. 1845.

L. guayaquilense HBK. Nov. Gen. et Sp. Pl. **3**: 50. 1818 = Acnistus guayaquilensis (HBK.) G. Don, Gen. Hist. Dichl. Pl. **4**: 461. 1838.

L. halophilum Speg. Anal. Soc. Cient. Argent. (Nov. Add. Fl. Patag.) **53**: 168. 1902. Since no material has been seen which can be referred to this species, the identity is uncertain; however, it is felt that Spegazzini's plant is close to *L. infaustum* Miers, but that it is probably a valid species, as are most of Spegazzini's species in this genus.

L. Herzogii U. Dammer, Meded. Rijks Herb. Leid. 29: 24. 1916. Judging from the description and a photograph of the type collection at Berlin (G), this plant is not a member of the genus *Lycium*, but its true identity is not known by the writer.

L. heterophyllum Murr. in Comm. Götting. **6**: 6, *pl. 2*. 1785 = Grabowskia.

L. horridum HBK. Nov. Gen. et Sp. Pl. **3**: 52. 1818, identity uncertain. Judging from the description and the plate of *L. obovatum* Ruiz & Pavon, Fl. Peruv. **2**: 46, *pl. 183, fig. c*. 1799, the writer is inclined to believe that these two species are one and the same, and should be retained in the genus *Lycium*.

L. ignarum Miers, Ann. & Mag. Nat. Hist. II, **14**: 194. 1854, and Ill. S. Amer. Pl. **2**: 129, *pl. 72A*. 1857. Original locality unknown, but seemingly from South America, and conspecific with L. ciliatum Schlecht.

L. loxense HBK. Nov. Gen. et Sp. Pl. **3**: 53. 1818 = Iochroma loxense (HBK.) Miers, Hook. Lond. Jour. Bot. **7**: 347. 1848.

L. macrophyllum Benth. Pl. Hartw. 49. 1840 = Acnistus macrophyllus (Benth.) Standl. Contr. U. S. Nat. Herb. (Trees & Shrubs Mex.) **23**: 1288. 1924.

L. melanopotamicum Niederlein in Roca, Exped. Rionegro **2**: 261. 1881. No material has been seen which can be referred with certainty to this species. The description and a photograph of the type collection at Berlin (G) would indicate that the plant belongs to the *chilense* complex.

L. Meyenianum Nees, Nov. Act. Acad. Caes. Leop. **19**, suppl. 1: 389. 1843, identity uncertain, but it seems not unlikely that the plant is a *Dunalia*, judging from the description which gives the corolla length as 15 lines.

L. microphyllum Willd. ex Roem. & Schult. Syst. Veg. **4**: 698. 1819 = L. parvifolium R. & S. *l. c.*

L. nanum Philippi, Anal. Univ. Chil. **91**: 25. 1895. Identity

uncertain, but if it is really a *Lycium* it is probably a valid species. Reiche, Fl. Chil. **5**: 318. 1910, placed the plant under *Verbena uniflora* Phil.

L. obovatum Ruiz & Pavon, Fl. Peruv. **2**: 46, *pl. 183, fig. c.* 1799 = Dunalia obovata (Ruiz & Pavon) U. Dammer in Engl. Bot. Jahrb. **50.** Beibl. 111: 56. 1913, acc. Macbride, but see under *L. horridum* HBK, preceding.

L. obtusum Willd. ex Roem. & Schult. Syst. Veg. **4**: 698. 1819, identity uncertain, but probably an Acnistus.

L. ovale Willd. ex Roem. & Schult. Syst. Veg. **4**: 698. 1819. This plant, *L. ovatum* Willd., is placed in *Iochroma* (*Chaenesthes*) *cornifolia* by Miers, but the descriptions are too inadequate for the writer to draw any conclusion as to its generic status, other than that it is evidently not a species of *Lycium.*

L. ovatum Hort. Monsp. ex Dunal, DC. Prodr. **13**[1]: 506. 1852 = Fregirardia luteiflora Dunal, *l. c.*

L. ovatum Willd. ex Dunal, DC. Prodr. **13**[1]: 527. 1852 (see under *L. ovale* Willd.).

L. parvifolium Roem. & Schult. Syst. Veg. **4**: 698. 1819. The diagnosis is too meagre to enable one to determine definitely the affinity of the species. Miers transferred it to *Lycioplesium* (*Acnistus*).

L. peruvianum Hort. ex Dippel, Hand. Laubholze **1**: 30. 1889 = L. obovatum Ruiz & Pavon.

L. pruinosum Griseb. Abhandl. König. Ges. Wiss. Gött. (Symb. Fl. Arg.) **24**: 245. 1879 = Grabowskia sp.

L. pulchellum Mart. & Gal. Bull. Acad. Brux. **12**[1]: 145. 1845. It has been impossible to locate this type; the description does not adequately portray the plant, but it is very strongly suspected that it may be a small-leaved plant of *L. pallidum* Miers. Miers transferred it to *Lycioplesium* (*Acnistus*) *pulchellum* Miers.

Lycium quitense Hook. Ic. Pl. **7**: *pl. 723.* 1844 = Poecilochroma quitensis Miers, Hook. Lond. Jour. Bot. **7**: 368. 1848.

L. rhadinum Philippi, Anal. Univ. Chil. **91**: 24. 1895, is probably some form of L. chilense Miers, but the description alone is not adequate to warrant a definite conclusion.

L. salsum Bartr. Trav. ed. 2, 57. 1792. The identity of this species cannot be ascertained, although other workers have as-

sumed that it is *L. carolinianum* Walt. The description is entirely inadequate to warrant any conclusion as to its true relationship; it could be either *L. carolinianum* Walt., or *L. halimifolium* Mill., the latter species being more "willow-leaved" than *L. carolinianum.* It is entirely possible that the plant was not even a *Lycium.*

L. salsum Ruiz & Pavon, Fl. Peruv. **2**: 46, *pl. 183, fig. a.* 1799, is probably the same as *L. Tweedianum* Griseb., but possibly is *L. chilense* Miers.

L. scabrum Nees, Nov. Act. Acad. Caes. Leop. **19**, suppl. 1: 389. 1843, is probably the same as *L. distichum* Meyen, from which species Nees segregated it.

L. spathulatum Ruiz & Pavon, Fl. Peruv. **2**: 46, *pl. 183, fig. b.* 1799 = Acnistus spathulatus Ruiz & Pavon.

L. spathulatum Mathews ex Dunal, DC. Prodr. **13**^{1}: 484, 527. 1852 = Dunalia acnistoides Miers.

L. Spencerae Macbride, Contr. Gray Herb. N. S. **53**: 18. 1918 = Prunus fasciculatus Gray. (see Munz & Johnst. Bull. Torr. Bot. Club **49**: 356. 1922).

L. stenophyllum Remy in Gay, Hist. Chil. Bot. **5**: 94. 1849, is possibly the same as *L. elongatum* Miers, but identity uncertain; may be same as *L. minutifolium* Remy.

L. Tweedianum Griseb. var. *heterophyllum* Hassler, Mus. Farm. Fac. Cienc. Buenos Aires **21**: 107. 1909. The type, *Rojas 514*, has not been seen, and the identity is not clear, but possibly some form of *L. Tweedianum.*

L. umbellatum Ruiz & Pavon, Fl. Peruv. **2**: 45, *pl. 182, fig. b.* 1799 = Acnistus umbellatus (Ruiz & Pavon) Miers, Hook. Lond. Jour. Bot. **4**: 342. 1845.

L. umbrosum HBK. Nov. Gen. et Sp. Pl. **3**: 54. 1818 = Iochroma umbrosa Miers, Hook. Lond. Jour. Bot. **7**: 346. 1848.

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Collector's numbers are printed in *italics;* unnumbered collections are indicated by a dash; the numbers inside the parentheses indicate the species to which the collector's numbers are assigned.

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Castellanos, A. — (12); — (14); — (14a); — (16); — (17); — (41); — (43); — (44).

Chapman, A. W. — (19).
Chase, V. H. *1534* (1).
Childs, L. J. — (34).
Claren, Fritz. *11722* (14a).
Claude-Joseph, Bro. *1729*, *2149*, *2224*, *2507* (41).
Clemens, Mrs. Jos. — (29).
Cleveland, D. — (45).
Clute, W. N. *4* (36).
Cocks, R. S. *3213* (1).
Colchester, Lord — (13), cf. I. M. Johnst. Contr. Gray Herb. **81**: 106. 1928.
Comber, H. F. *127* (40); *28* (41).
Cooper, J. G. — (30); — (37); *468* (45).
Cottam, W. P. *4015* (30); *2520*, *2543*, *C4795* (36).
Coues, Elliott, and Edward Palmer. *190*, *361* (36).
Coville, F. V. *1896*, *1897* (20); *1869* (30); *1616* (35); *1903* (36).
Coville, F. V. and F. Funston. *879* (29); *826*, *907*, *929* (37).
Crawford, D. L. —, *741* (45).
Cuming, H. *948* (26); *367* (41).
Curran, H. M. *103* (6); *95* (23); *103* (43).
Curran, H. M. and M. Haman. *447*, *750*, *939*, *1162*, *1250* (10).
Curtiss, A. H. *2216*, *6543* (19).
Darwin, Chas. *509* (41).
Davidson, A. *1013* (29a); *164* (36); — (37).
Davis, John. *1336* (1).
Davis, T. W. — (30).
Deam, Mrs. C. C. — (19).
Dewey, L. H. — (30).
Diehl, I. E. — (36).
Diguet, Leon. — (21).
Dodge, C. K. *60* (20).
Donat, A. *176* (27); *170* (33); *147* (41); *37* (44).
Drake. — (29).
Driver, Mr. and Mrs. — (36).
Drummond, T. *244* (19a).
Drushel, J. A. — (19a).
Dudley, W. R. — (34); — (37); — (45).
Durant, M. — (36).
Dusén, P. *40* (14); *5467* (33); *5239* (41).
Earle, F. S. *650* (20); *466* (30); *637* (36).
Eastwood, Alice. — (20); *7745* (20a); — (20d); — (21); — (21a); *6015*, *6172* (29); *2641* (29b); —, *2785*, *6139*, *6321*, *8017*, *8027*, *8673*, *15790*, *17063*, *17475*, *17746* (34); *8117*, *17794*, *17795*, *17815*, *17795*, *17826*, *17863*, *17864* (35); *5540*, *5594*, *6108*, *8390*, *15549*, *16752*, *17447a*, *17625* (36); *3274* (37); *8028*, *8082* (38); —, *163* (45).
Eaton, A. A. *52* (19).
Eby, J. H. — (29a).
Eggers, H. F. A. von. *14964* (10).
Eggleston, W. W. *19809* (29); *14363* (36).
Ekman, E. L. *955*, *H955*, *2925*, *6728*, *6729*, *10236*, *15741* (10a).
Elliott, Clarence. *211* (41).
Ellis, C. C. *150* (36).
Ellis, Miss Charlotte. *469* (36).
Elmer, A. D. E. *3757* (29); *3661* (37).
Engelmann, G. — (29a); — (45).
Engelmann, H. — (37).
Epling, C. C. — (29b).
Escuela Centenario. *77* (5).
Evans, W. H. *3397* (30).
Evermann, B. W. — (45).
Fendler, A. —, *668b*, *670* (36).
Fernald, M. L., Bayard Long, and G. S. Torrey. *10346* (1).
Fernon, B. E. — (36).
Ferris, R. S. *1305*, *7904* (29); *1013*, *1130* (30); *1229* (36); *7254*, *7432*, *7912* (37).
Ferris, R. S. and C. D. Duncan. *3145*, *3210* (20); *2511* (20d); *2209* (29); *2319*, *2443* (30).
Ferruglio. — (33); — (41); — (44).
Feudge, J. B. *1831* (21).
Field Biology Class of Dixie College. *S32* (30).
Fischer, Walter. *80* (14); *112* (27); *17* (41); *132* (44).
Fish, Miss F. E. — (21).
Fisher, A. K. *2807* (36).
Fisher, G. L. *1740*, *1741*, *5161* (19a).
Fitch, Rev. A. — (21).
Fleming, S. L. *1* (21).
Fosberg, F. Raymond. *S3748*, *S3875* (20a); *S3361*, *S3417*, *S3642* (30).
Fredholm, A. *5506* (19).

Fremont's Exped. to Calif. — (30); — (34); — (38).
Fremont, J. C. *474* (36).
Fries, R. E. *1430* (3); *1385* (5); *351*, *1032* (6); *1473* (7); *1652* (9); *200* (10); *649*, *664* (14a); *783*, *794* (17); *751* (41); *173* (43).
Fuertes, Pater. *547* (10a).
Fulton, H. J. *6436* (31); *6435* (35).
Galander, C. — (6); — (23); — (43).
Gandoger, M. — (43).
Ganong, W. W. and R. Blaschka. — (34).
Garber, A. P. — (19).
Gardner, G. —, *1370* (5).
Garrett, A. O. — (29).
Gaudichaud, C. *83* (13); *117* (41).
Gaumer, G. F. *1248*, *1351*, *2286*, *23162* (19b).
Gay, M. Cl. — (24); — (25); — (27); — (41).
Geis, H. D. —, *581* (45).
Geisse, William. *40* (26).
Germain, Ph. — (41).
Gibert, M. E. *6411* (5); *18* (6).
Gigoux, Enrique Ernesto. — (41).
Gillies, J. — (14); — (27); — (41).
Gilman, M. F. *24* (21); *29* (29); *2408* (38).
Goldman, E. A. *1789* (20a); *1163* (21); *1444*, *1459*, *2315*, *2958* (29); *1615* (29a); *1503*, *1645*, *1799* (30); *1586*, *2053* (36).
Gomez. — (23).
Goodding, L. N. *2147*, *2305* (29); *714* (29a); *633* (30); *878* (36); *2160* (37).
Goodman, G. J. and C. L. Hitchcock. *1135* (20a); *1137* (29); *1235* (29a); *1138* (30); *1136*, *1150*, *1237* (36).
Grabendorffer, C. — (19a); — (20c).
Grant, G. B. *12469* (21a); — (45).
Grant, G. B. and W. Wheeler. *739a/6151* (21a); *H2447* (45).
Gray, A. — (29b); — (34); — (45).
Greata, G. B. *6157* (21a).
Greene, E. L. — (36).
Gregg, J. *199* (20a).
Griffiths, David. *6352* (20); *3463* (20a); *3908*, *5955* (20d); *3623*, *6921*, *6955* (29); *3642*, *3751* (29a); *3995* (31); *2099*, *2224*, *3688*, *4042*, *4055* (34); *2290* (35); *3681*, *3683*, *4130* (36); *4031* (38); *2216*, *4052* (45).
Griffiths, David, and J. J. Thornber. *20* (29).
Grinnell, Fordyce. *415*, *444*, *447* (37).
Grinnell, Jos. — (29); — (37).
Hall, H. M. *2800* (30); *6031*, *6194* (37); *3959* (45).
Hall, H. M. and E. B. Babcock. *4462* (1).
Hanson, H. C. — (19a); *786* (20); *A129* (29); *A130* (36).
Hanson, H. C. and E. E. *A1025* (35); *A641* (36).
Harrison, G. J. *1784* (20a); *955* (34); *3584* (39).
Harrison, G. J. and T. H. Kearney. *6538*, *6560* (31); *6571* (38).
Harrison, G. J., T. H. Kearney and H. J. Fulton. *7295* (20b); *7523*, *7524*, *7526*, *7527*, *7529*, *7579*, *7611*, *7625*, *7626*, *7627* (29); *7528*, *7558* (34); *7530*, *7614* (37); *7525* (38).
Hart, Cecil. — (29); — (36a); *1*, *61* (37).
Hartman, C. V. *212* (35).
Hasse, H. E. —, *4155* (21a); — (37).
Hassler, E. *7201* (2).
Hastings, G. T. *50*, *169* (41).
Hauman, L. — (8); — (23); — (27); — (41); — (43).
Havard, V. *161* (19a); —, *90*, *156*, *157* (20); —, *154*, *155* (20d); *89*, *160* (31); —, *91*, *158*, *159* (39).
Hayes, Sutton. — (36); — (39).
Heller, A. A. *1395* (19a); *2093* (19c); —, *7704* (29).
Heller, A. A. and E. G. *3599* (36).
Heller, A. A. and E. G. Halbach. *1171* (1).
Herre, A. C. — (45).
Herrick, C. L. *235* (30); *263*, *894* (36).
Herter, Guil. *279*, *279a* (6).
Herzog, Th. *1097* (3); *1095* (10).
Hieronymus, G. —, *493*, *593* (6); — (23); —, *494* (41); —, *113* (43).
Hieronymus, G. and G. Niederlein. *772* (17); *269* (27); — (41); *179*, *345* (43).
Hilend, Martha. —, *370* (29); *384* (29b); *383* (37).

Hinds, Richard Brisley. — (10).
Hioram, Bro. *2273* (10a).
Hitchcock, A. S. *21111* (10); —, *241* (19).
Hoffmann, Ralph. — (21a); — (29); — (30); — (34); — (36a); — (37).
Höfsten, G. v. *833* (27a).
Holzner, F. X. *2649* (29a).
Hough, W. *71* (36).
Howell, A. H. *285* (19a); *279* (20).
Howell, J. T. *3210* (21a); *2528*, *3274*, *3657*, *4998* (29); *3530* (34); *2502*, *4999* (37).
Huger, A. M. — (19).
Illin, Nicolas. — (27); *187* (41); —, *73* (44).
Jaeger, E. C. — (21); *1159* (37).
Jaffuel, Felix. *881* (41).
Jameson, Dr. William. — (14a); — (15); — (16); — (41).
Jepson, W. L. *6612* (29); *5484* (30); *4779*, *6148*, *6606* (36a); *5329*, *6636* (37).
Jermy, Julius. *66* (20).
Jörgensen, P. *2208* (2); *970*, *11511* (6); *2825* (9); *976* (15); *971* (43).
Johnston, I. M. *3027*, *3061*, *3154*, *3215*, *3233*, *3425*, *3747* (21); *3662*, *4706*, *4866*, *4934* (24); *5382* (26); *6120*, *6172* (28); —, *2028*, *2272* (29); *1035* (30); *4829* (32); *3040* (34a); —, *1767*, *1769* (37); *4989* (41); *6121* (42); *1949* (45).
Johnston, J. R. *8*, *61* (10).
Jones, M. E. *24400* (19a); *22517*, *23102*, *24111*, *24398* (20c); —, *22518* (20d); —, *3714*, *22516*, *22597* (21); —, *1624*, *3045*, *4276*, *5064as*, *5125p*, *5139* (29); — (29a); — (29b); *1624*, *3730*, *5015*, *5030h* (30); *24159* (34a); — (35); —, *3903*, *5215a*, *5224t* (36); — (36a); —, *5012*, *5045af* (37); *26242* (39); —, *3045* (45).
Jones, W. W. *231* (1); —, *75* (36).
Jurado, Doello. — (5).
Kammerer, A. L. *25* (36).
Kearney, T. H. *112* (29a); *122* (34).
Kearney, T. H. and G. J. Harrison, *6554* (31).
Kennedy, P. B. *7100* (20a); *1816* (30).
King, Alice. — (45).
King, Capt. — (41).
Knopf, E. C. *509* (21a); *332*, *419* (45).
Knowlton, F. H. *214* (36).
Kuntze, Otto. — (2); — (6); — (14); — (16); — (23); — (41); — (43).
Kunze, R. E. — (34).
Langlois, A. B. —, *242* (19a).
Lansing, O. E. *2012* (19).
Lechler, — (41).
Leiberg, J. B. *3184* (29).
Lemmon, J. G. — (29); — (30); — (34); —, *217*, *3245* (36); — (37); — (45).
Lemmon, Mr. & Mrs. J. G. — (37).
Leon, Fre. *12122* (10a).
Leonard, E. C. *3345* (10a).
Leonard, E. C. and G. M. *11047* (10a).
Lindheimer, F. — (19a).
Lindley, J. — (13).
Lloyd, F. E. *137* (20d); — (34).
Lloyd, F. E. and S. M. Tracy. *48* (19a).
Löfgren, A. W. *487*, *523*, *749* (4).
Long, Frances. *33* (20); *32* (30).
Loomis, H. F. *6908* (36); *698* (45).
Loomis, Mrs. H. F. *968* (38).
Looser, G. *773*, *968* (41).
Lorentz, P. G. *32* (6); — (10); *30*, *131* (23); —, *154* (27); —, *109* (41).
Lorentz, P. G. and A. Grisebach. — (3); — (10); — (43).
Lorentz, P. G. and G. Hieronymus. *363* (3); — (6); *744*, *745* (14a); — (23); — (41).
Lossen, W. *81* (6); *304* (43).
Lumholtz, Carl. *29* (29a).
Lutz, F. E. *F4040E* (29a).
MacDougal, D. T. — (21); *10* (30); *140* (34).
MacDougal, D. T. and F. Shreve. *21* (21).
Mackenzie, K. K. *98* (31).
Macrae, James. — (13); — (41).
Malme, G. O. A. *2873* (41).
Mann, H. and W. T. Brigham. *596*, *597* (19c).
Mason, H. L. *1918*, *2014*, *2048*, *2073* (21).
Mathews. *450* (10).
Mathews, Dr. W. — (36).
McAtee, W. L. *1907*, *1908*, *1909* (19a).
McClatchie, A. J. *514* (21a).

McDougal, T. M. — (36).
McKelvey, Susan D. *875, 1128* (34); *878, 879* (35); *1077* (36).
McGregor, E. A. *2050* (21).
McMinn, H. E. *1462* (30).
Mearns, Dr. E. A. *1490* (30); *2717, 2733* (34); *304, 349, 2327, 2740* (36).
Mell, C. D. — (10); — (19).
Merritt, A. O. — (29b).
Metcalfe, J. K. *1282* (30); *2, 42, 1590* (36).
Mexia, Ynes. *83, 1011* (19a).
Mex. Bound. Surv. *1028* (20); *1029* (30); *1027* (36).
Meyen, F. J. F. — (25).
Middleton, Capt. — (41).
Miers, J. *735* (14); *328, 651* (41).
Miller, Mrs. C. E. — (45).
Miller, G. S. *327* (19).
Miller, S. S. and J. R. Johnston. *153* (10).
Millspaugh, C. F. *206, 213* (36); *4450, 4612, 4778* (45).
Millspaugh, C. F. and C. M. *9084, 9292* (10a).
Minthorn, Mabel. — (36a).
Mohr, Chas. — (19).
Mohr, P. F. — (34).
Molfino. — (6); — (8).
Monnet, P. *1098* (29b); *1131* (34).
Montero, G. *74, 210* (41).
Moreau, Pérez. — (41).
Moreno, F. P. and Tonini. *240* (18); *527, 528* (41).
Morong, Thos. *161* (2); *1006* (10); *1116* (41).
Moseley. — (41).
Mulford, A. I. *1049a* (20a); *603* (36).
Munson and Hopkins. — (30).
Munz, P. A. *1424* (20); *9964* (21); *2606, 4710, 5115* (29); *1270* (30); *8999* (37); *2196, 6648* (45).
Munz, P. A. and C. L. Hitchcock. *12256* (30); *12098* (31); *12284* (36a).
Munz, P. A. and I. M. Johnston. *5200a* (29); *5200b* (37).
Munz, P. A., I. M. Johnston, and R. D. Harwood. *4026a* (29); *4026* (37).
Munz, P. A. and D. D. Keck. *4811, 4849, 4850* (29).
Nash, V. G. and Norman Taylor. *1321* (10a).
Nation, W. — (10).
Nealley, G. C. — (20).
Nelson, E. W. *3904* (20a); *71* (29).
Nelson, E. W. and E. A. Goldman. *7327, 7350* (20c); *7105, 7163, 7269, 7487* (21); *7322, 7488* (34a).
Nelson, J. C. *4903* (1).
Nevin, J. C. — (45).
Newberry, J. — (36).
Nuttall, L. W. *258* (45).
Nuttall, T. — (45).
d'Orbigny, A. *183* (27).
Orcutt, C. R. *1269, 6000* (20); —, *2020* (21); — (29); — (45).
Ortega, J. G. *6014* (19a); *5561* (21); *5520* (29).
Oyster, J. H. — (30).
Palmer, Edward. *377* (19); *201, 953* (19a); *950, 951, 952, 956, 957* (20); *112, 247, 490, 954* (20a); *230* (20c); *285, 955* (20d); —, *71, 183* (21); *4* (21a); —, *101, 365, 418, 421, 426, 559* (29); —, *199* (29a); —, *365, 366, 424, 425* (30); — (31); *200, 422, 423* (34); *13* (34a); —, *367, 419* (36); —, *66, 223½, 364, 420* (37); —, *63, 146, 178, 262, 916* (45).
Palmer, E. J. *27481* (19); *8528* (19a); *11134, 12955* (20); *13537* (20d).
Pammell, L. H. and Rob. Combes. *203* (1).
Parish, S. B. *11, 2437, 11655* (29); *1203, 4132* (29b); *781, 8491* (30); —, *795* (31); — (34); *2438, 2989, 9048, 9695, 11847* (37).
Parish, S. B. and W. F. *11, 11A, 730* (29); *781, 781a* (30); *795* (31); —, *180, 8512* (34); —, *1196* (37).
Parish, W. F. —, *180* (34); *179* (45).
Parodi, L. R. *8702* (6); *8580* (14); *8577* (27); *8583, 8601* (41).
Parry, C. C. *12* (20c); —, *12* (21); —, *201, 204, 216, 216½, 314* (29); *202* (30); — (34); —, *216* (45).
Parry, C. C. and J. G. Lemmon. *270* (29b).
Parry, C. C. and E. Palmer, *656½* (20); *654, 654½* (20a); *655* (36).

Parry, C. C. and C. G. Pringle. — (29).
Parry, C. C., C. G. Pringle, and C. H. T. Townsend. — (29).
Pavon, J. — (10).
Payson, E. B. *1124* (36).
Pearce, R. — (7); — (24); — (26); — (27).
Peebles, R. H. *6445* (29); *7389* (29a); *6426* (29b); *6446* (30); *6795, 7709* (31); *719, 6412, 6428, 6429, 6444, 6447, 6448, 6449, 6450, 6451, 6452, 6453, 7475, 7478* (34); *6392, 6397, 6404, 7467, 7476, 7485, 7486, 7487, 9841* (35); *6442, 6455, 7484, 7510* (38); *7489* (45).
Peebles, R. H. and G. J. Harrison. *1853* (20b); *6431* (29); *97, 2723* (29a); *1165, 5045* (30); *5007* (31); *1166, 3970, 6457, 6459* (34); *6461* (38); *3546, 6464* (45).
Peebles, R. H., G. J. Harrison, and T. H. Kearney. *144* (20d); *404* (29a); *4920* (31); *227* (34); *3288, 5217* (35).
Peebles, R. H. and T. H. Kearney. *97* (29a); *6702* (38).
Peebles, R. H. and C. J. King. *7508, 7509* (45).
Peebles, R. H. and H. F. Loomis. *6774* (20a); *6761* (20b); *6431, 6727, 7500, 7501, 7502* (29); *7497* (31); *6430, 7451, 7456, 7457, 7458, 7464* (35); *6432* (38).
Peebles, R. H. and I. B. Miller. *6417* (35).
Peirson, F. W. *1086* (37); *4526* (45).
Pendleton, *1421* (21a).
Philippi, R. A. — (13); — (14); — (24); — (26); — (27); —, *758* (32); —, *583* (41); — (42).
Pittier, H. *1604, 10373* (10).
Poeppig, E. *85* (= *238?*) (41).
Pollard, C. L., G. N. Collins and E. L. Morris. *182* (19).
Porter, T. C. — (19).
Price, Sadie F. — (1).
Price, W. W. — (34); — (36).
Pride, Andrew. — (10).
Pringle, C. G. *4174* (19a); —, *176* (20b); — (29a); *786* (30); — (31); — (34); — (35); — (37); — (38); — (45).
Purpus, C. A. *1089* (20a); *5427* (29); *155* (35); —, *7091* (36); —, *5408* (37).
Rapp, S. — (1).
Reed, E. C. — (41).
Reed, F. M. *1203, 5289* (29b).
Rehn, J. A. and H. L. Viereck. — (30).
Reverchon, J. *684, 3242* (19a).
Rich, Major. — (21).
Rodriguez. *166* (2); *1192* (2a); *176, 1145* (3); *762* (5); *217* (6); *550* (43).
Rojas, Theodore. *504* (9); *2637, 2707* (10).
Rolfs, P. H. *240* (19).
Rose, J. N. *18063* (19a); *16413* (20c); *1256, 1310, 1341, 16108, 16586, 16759* (21); *1314* (29); *2488* (36); *16057, 16065, 16076, 16253* (45).
Rose, J. N. and W. R. Fitch. *17688* (1).
Rose, J. N., W. R. Fitch and P. G. Russell. *4017* (10a).
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Sclerocarpellum 201, (325)
Selidophora 188, 201, (312)
Solaneae 197
Solaneae-Lycineae 197
Teremis 182, 199
Valteta 182
Verbenaceae 191
Verbena uniflora 334

Explanation of Plate

PLATE 12

Figs. 1–3. Photomicrographs of *Lycium macrodon* Gray, from *Peebles 7484*.

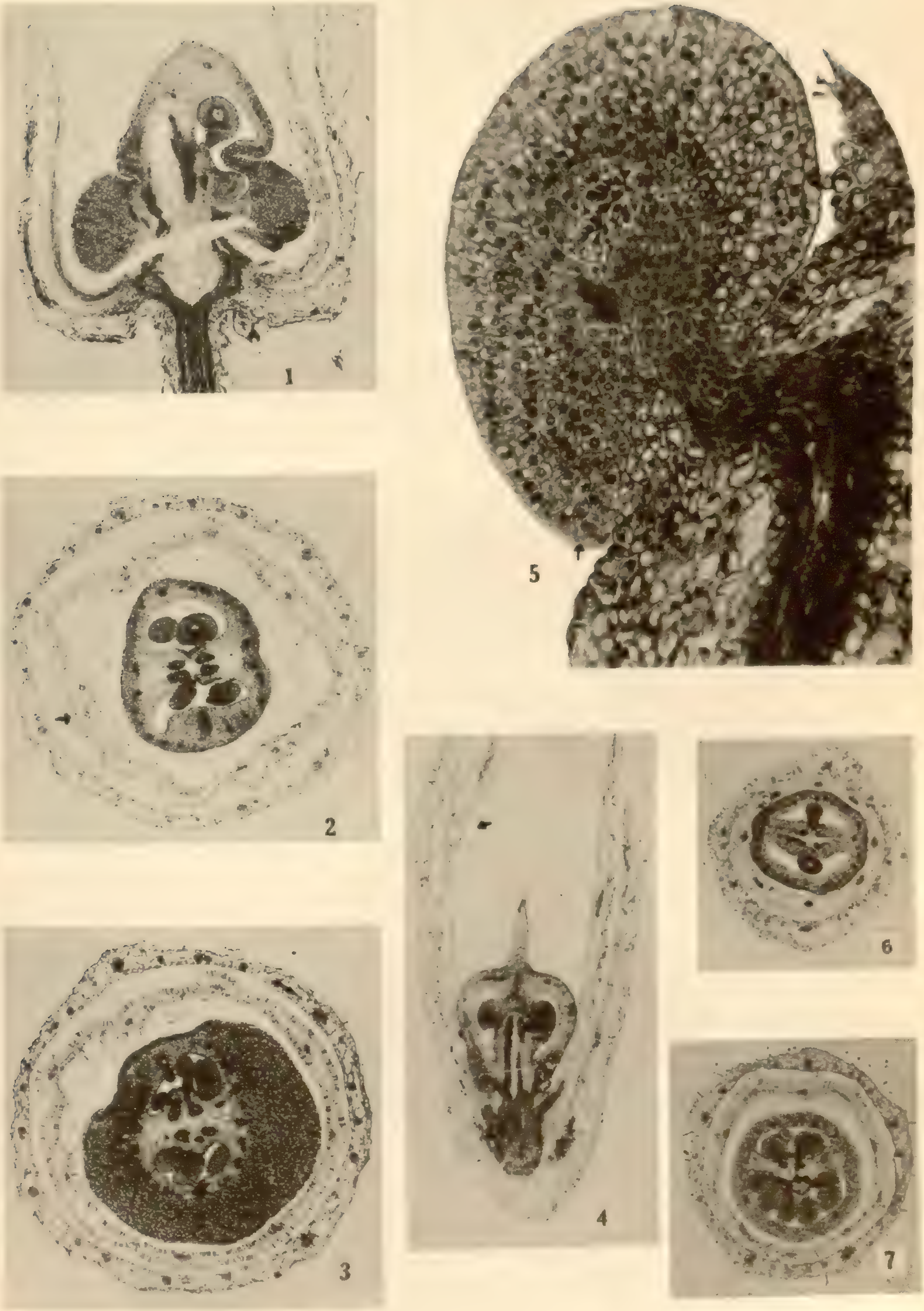
Figure 1 is a longitudinal section of a young ovary; the ovules in one carpel are shown. The upper part of the ovary, that which develops fertile seed, is shown on the right-hand side; below this the constriction is apparent, the pendulous ovules and thickened wall being notable. Figure 2 is a cross-section through the upper portion of the ovary, the vascular tissue of the ovary and the two ovules in each carpel being visible. The outer ring of tissue is the calyx; the middle ring is the corolla. Arrow marks the vascular trace of one filament; the pubescence on the corolla along this trace is discernible. Figure 3 is a cross-section through the lower portion or "disc" of the ovary; note the numerous ovules and thickened wall.

Figs. 4–6. Photomicrographs of *Lycium californicum* Nutt. ex Gray, from *Peebles 7489* (SAC).

Figure 4 is a longitudinal section of a young ovary, the ovule in each carpel being apparent. The arrow indicates a filament as it is freed from the corolla-tube. An ovule is shown in fig. 5, also the vascular trace running to the funiculus. Arrow indicates region of micropyle. A cross-section of the ovary is shown in fig. 6, the vascular traces and one ovule in each carpel being visible.

Fig. 7. Photomicrograph of *Lycium exsertum* Gray, from *Peebles 7476*.

The axile placentation, numerous ovules, and vascular traces are discernible, as is the pubescence on the outside of the calyx.



HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

COCKAYNE, BOSTON

Explanation of Plate

PLATE 13

Fig. 1. *Lycium macrodon* Gray.

Drawing of mature fruit; the upper portion bears 2–4 fertile seeds, the lower portion or "disc" contains abortive ovules only. × 4.

Figs. 2–5. *Grabowskia geniculata* (Fernald) C. L. Hitchcock.

Figure 3 is a drawing of one carpel shown from the ventral or commissural face; the two seeds are visible. Figure 4 shows one carpel with most of the commissural face removed, one ovule with its coiled embryo is shown. Figure 5 is a cross-section of the fruit, the stony endocarp being unshaded. Figure 2 shows the pericarp of one carpel viewed from the lower end. Figs. 2, 4, and 5, × 4. Fig. 3, × 5.

Fig. 6. *Lycium Cooperi* Gray.

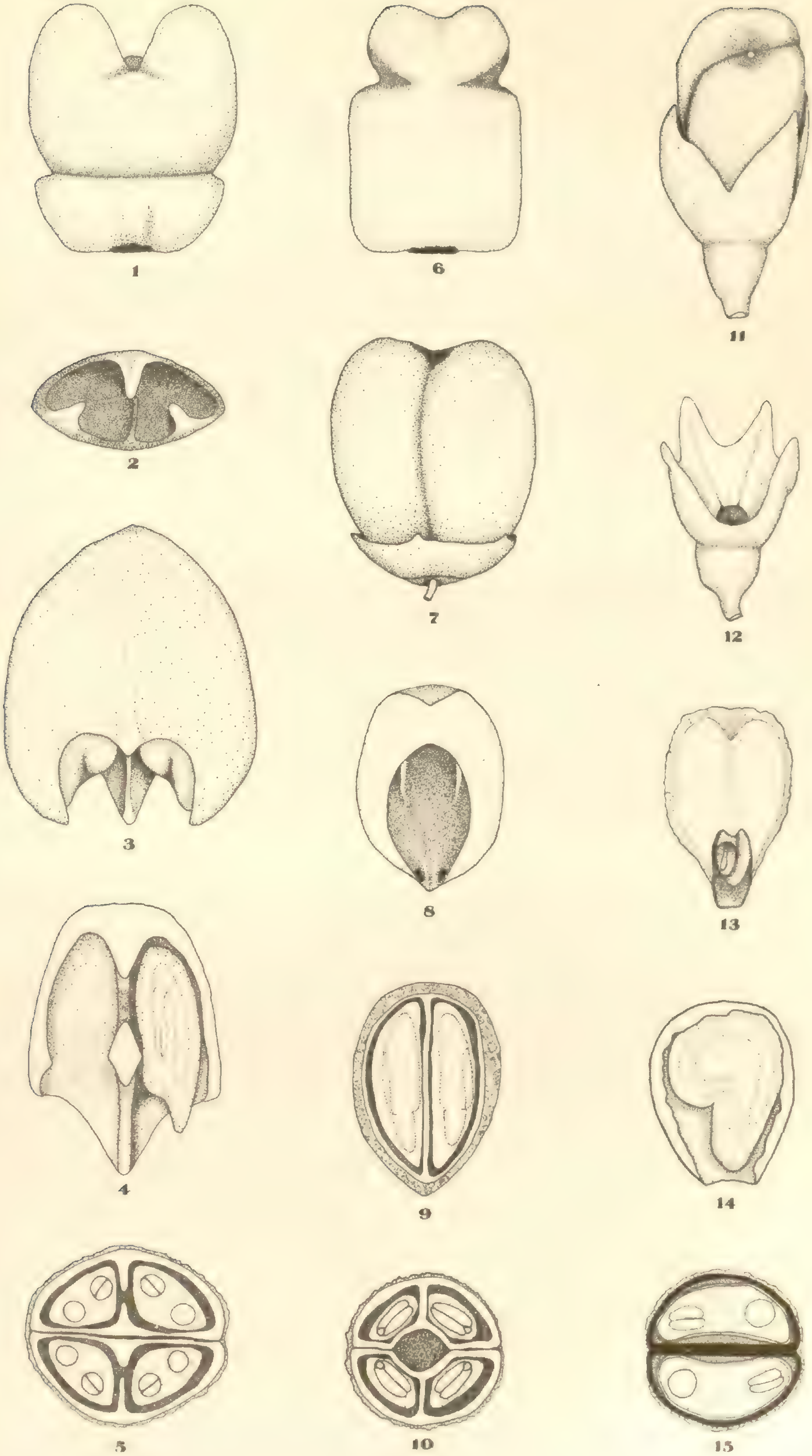
Drawing of mature fruit. The lower portion contains numerous seeds, the upper portion 1–2 seeds in each carpel. × 4.

Figs. 7–10. *Citharexylum brachyanthum* Gray.

Figure 7 is a drawing of the mature fruit and much-expanded calyx. Figure 8 shows one carpel viewed from the commissural face. Figure 9 is a drawing of one carpel, the pericarp being removed from the dorsal side, showing the median wall and two seeds. The embryo is straight, being represented in dotted lines. A cross-section of the mature fruit is shown in fig. 10; the stony endocarp is unshaded. Figure 7, × 5. Figs. 8, 9, and 10, × 4.

Figs. 11–15. *Lycium californicum* Nutt. ex Gray.

The mature fruit and calyx is shown in fig. 11, and the calyx in fig. 12. Figure 13 is a drawing of one carpel with the commissural face showing; the funiculus and seed are visible within the carpel. Figure 14 represents one carpel with the pericarp of the dorsal side removed, the funiculus and embryo being shown in dotted lines. Figure 15 represents a cross-section of the fruit; the stony endocarp is shown in solid black. All figures × 4.



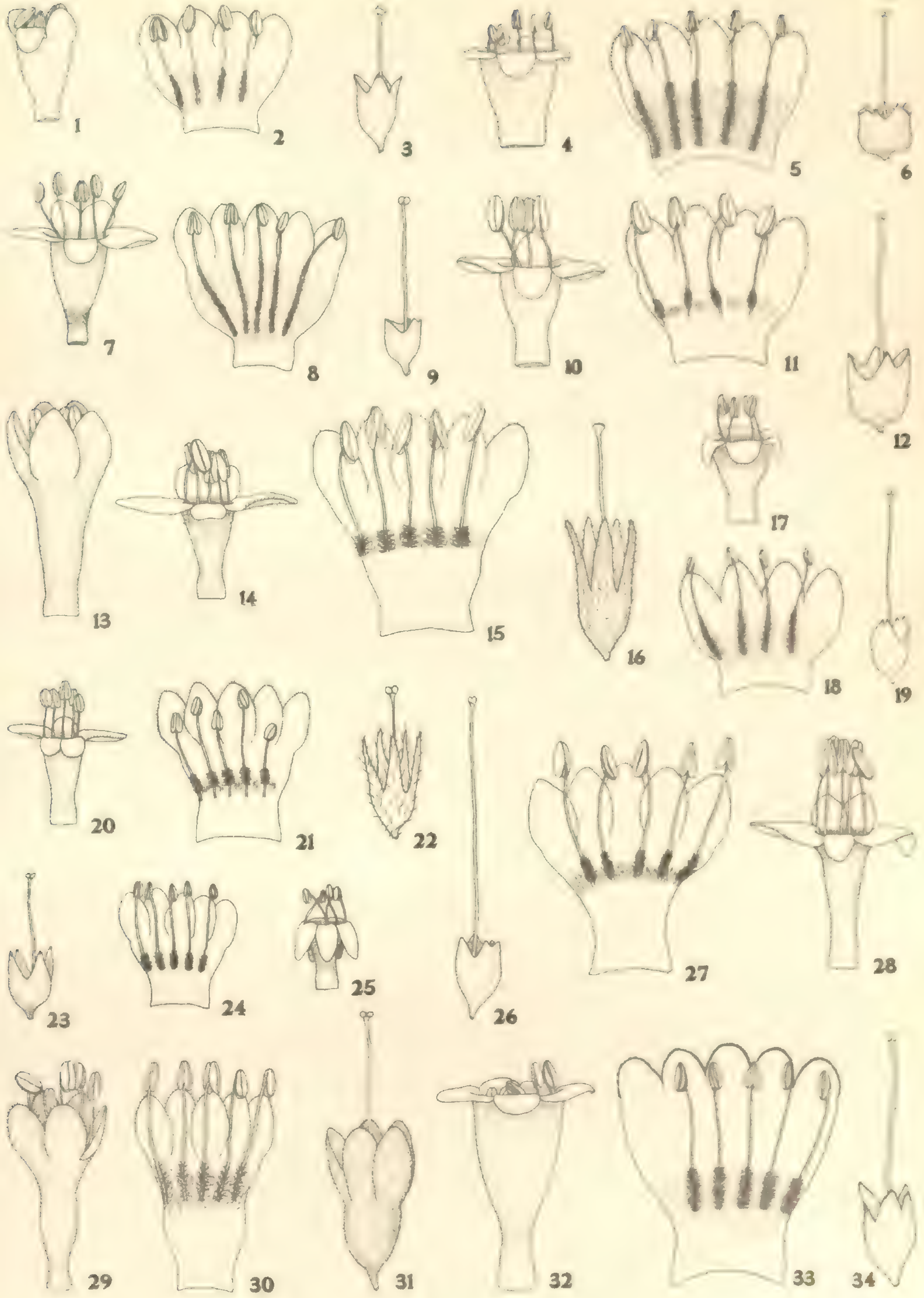
HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

Explanation of Plate

PLATE 14

Figs. 1–3. *Lycium Morongii* Britton.
Figs. 4–6. *Lycium Martii* Sendtner.
Figs. 7–9. *Lycium glomeratum* Sendtner.
Figs. 10–12. *Lycium vimineum* Miers.
Figs. 13–16. *Lycium tenuispinosum* Miers. Figure 14 is drawn from the type.
Figs. 17–19. *Lycium cuneatum* Dammer.
Figs. 20–22. *Lycium pubescens* Miers.
Figs. 23–25. *Lycium minimum* C. L. Hitchcock.
Figs. 26–28. *Lycium infaustum* Miers.
Figs. 29–31. *Lycium ovalilobum* C. L. Hitchcock.
Figs. 32–34. *Lycium cyathiformum* C. L. Hitchcock.

All figures × 3.



HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

Explanation of Plate

PLATE 15

Figs. 1–3. *Lycium Tweedianum* Grisebach.

Figs. 4–6. *Lycium Tweedianum* var. *chrysocarpum* (Urb. & Ekm.) C. L. Hitchcock.

Figs. 7–9. *Lycium Berlandieri* Dunal var. *longistylum* C. L. Hitchcock.

Figs. 10–12. *Lycium Berlandieri* Dunal.

Figs. 13–15. *Lycium Berlandieri* Dunal var. *brevilobum* C. L. Hitchcock.

Figs. 16–18. *Lycium nodosum* Miers.

Figs. 19–21. *Lycium pubitubum* C. L. Hitchcock.

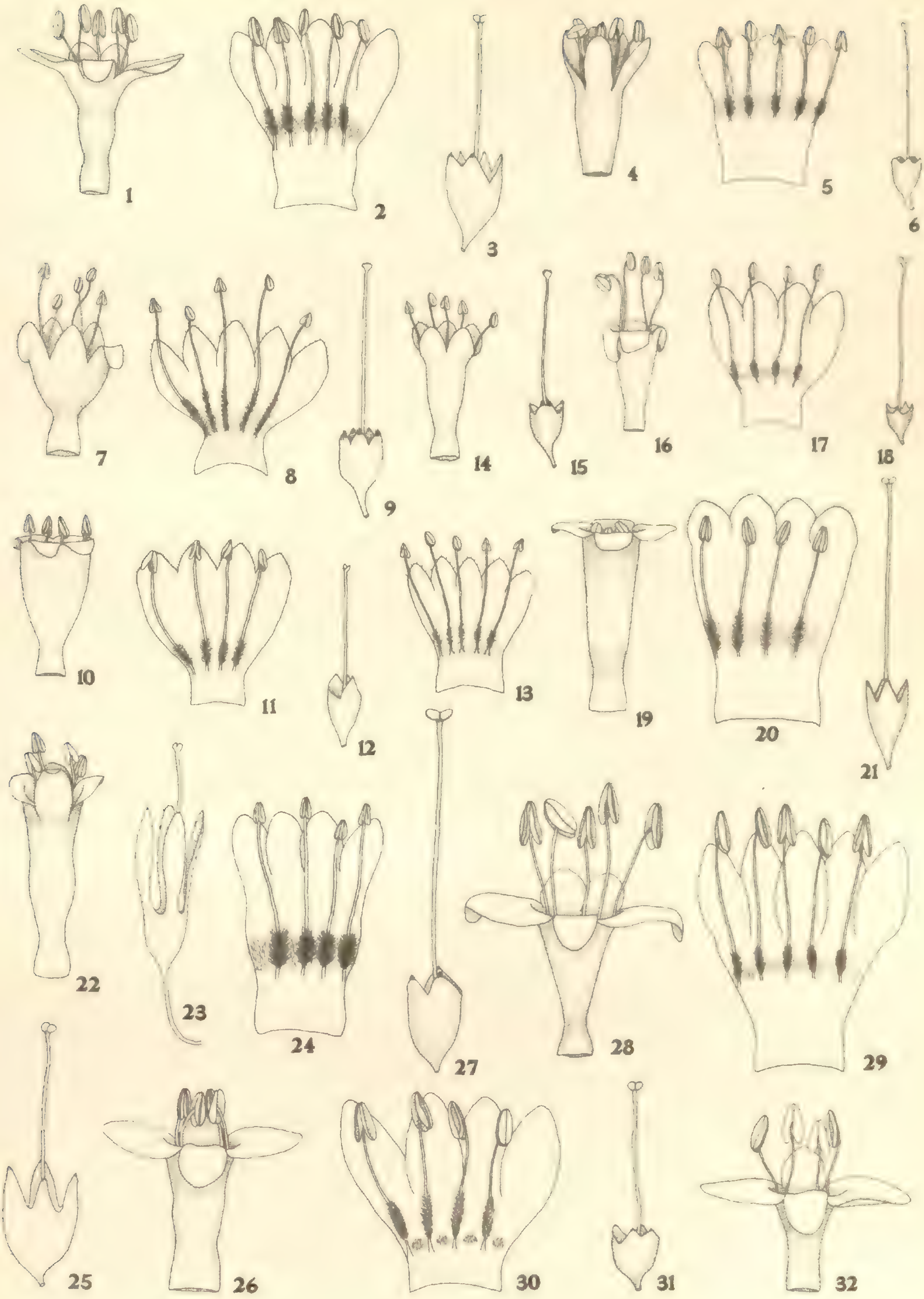
Figs. 22–24. *Lycium Richii* var. *Hassei* (Greene) I. M. Johnston.

Figs. 25–26. *Lycium Richii* Gray.

Figs. 27–29. *Lycium halimifolium* Miller.

Figs. 30–32. *Lycium carolinianum* Walter.

All figures × 3.



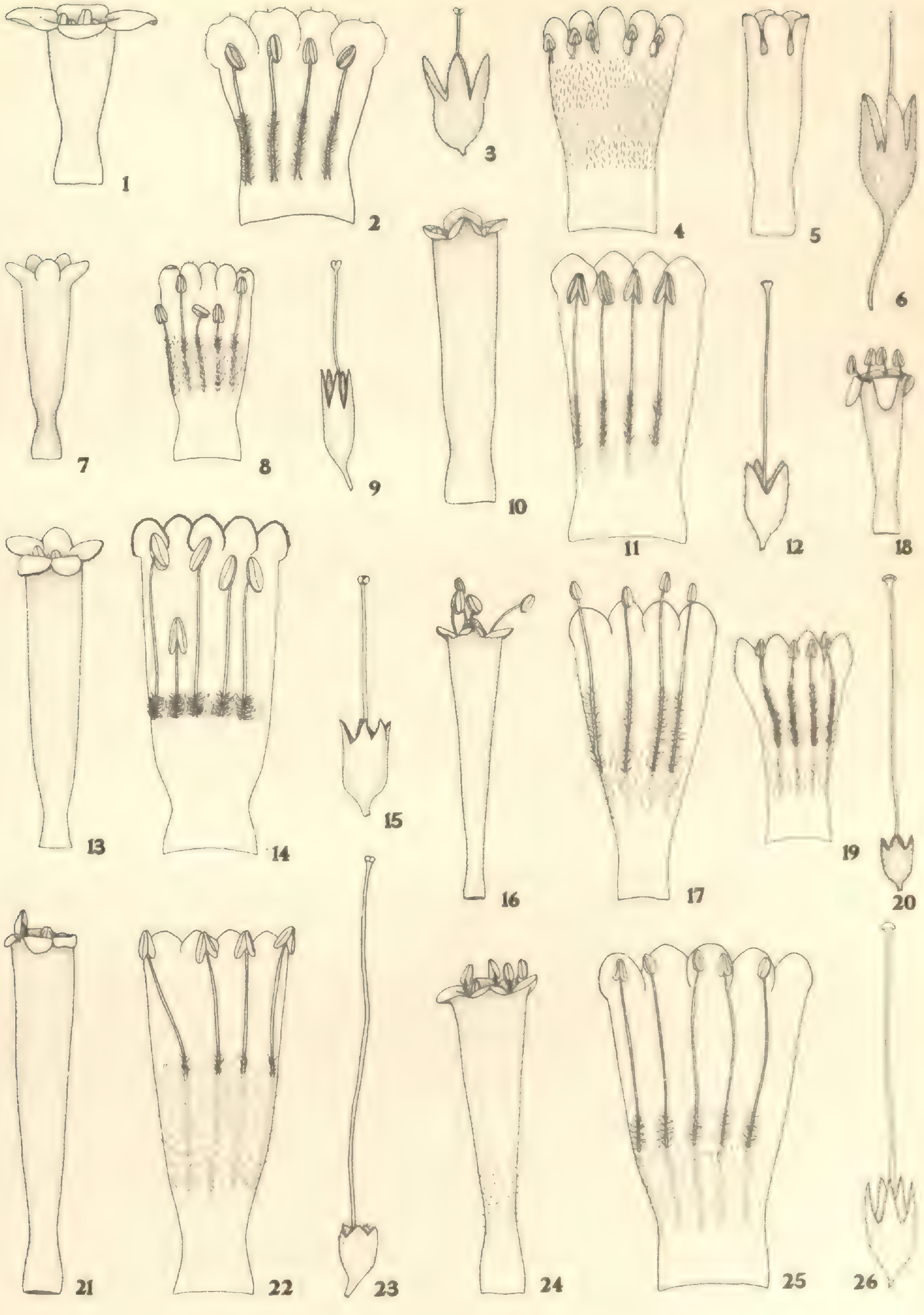
HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

Explanation of Plate

PLATE 16

Figs. 1–3. *Lycium decipiens* Dammer.
Figs. 4–6. *Lycium verrucosum* Eastwood.
Figs. 7–9. *Lycium elongatum* Miers.
Figs. 10–12. *Lycium fragosum* Miers.
Figs. 13–15. *Lycium cestroides* Schlechtendahl.
Figs. 16–20. *Lycium minutifolium* Remy.
Figs. 21–23. *Lycium Gilliesianum* Miers.
Figs. 24–26. *Lycium distichum* Meyen.

All figures × 3.



HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

Explanation of Plate

PLATE 17

Figs. 1–3. *Lycium fuscum* Miers.

Figs. 4–6. *Lycium repens* Spegazzini.

Figs. 7–9. *Lycium humile* Philippi.

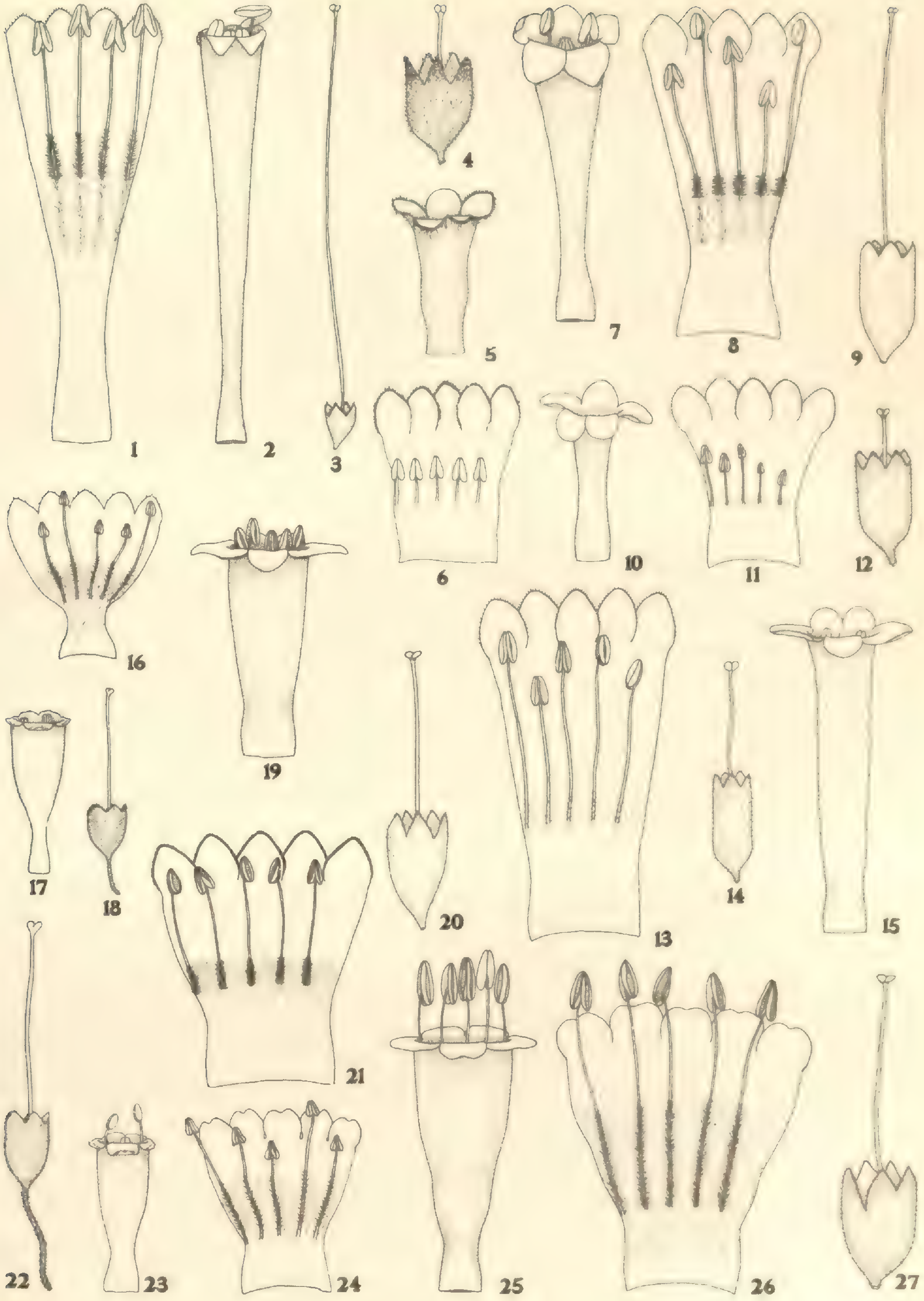
Figs. 10–15. *Lycium Fremontii* Gray. Figures 10–12 represent one common flower-type; figs. 13–15, the other extreme (the species being strikingly dimorphic).

Figs 16–18. *Lycium exsertum* Gray.

Figs. 19–21. *Lycium Torreyi* Gray.

Figs. 22–27. *Lycium exsertum* Gray. Figures 22–24 represent a flower with partially abortive stamens.

All figures × 3.



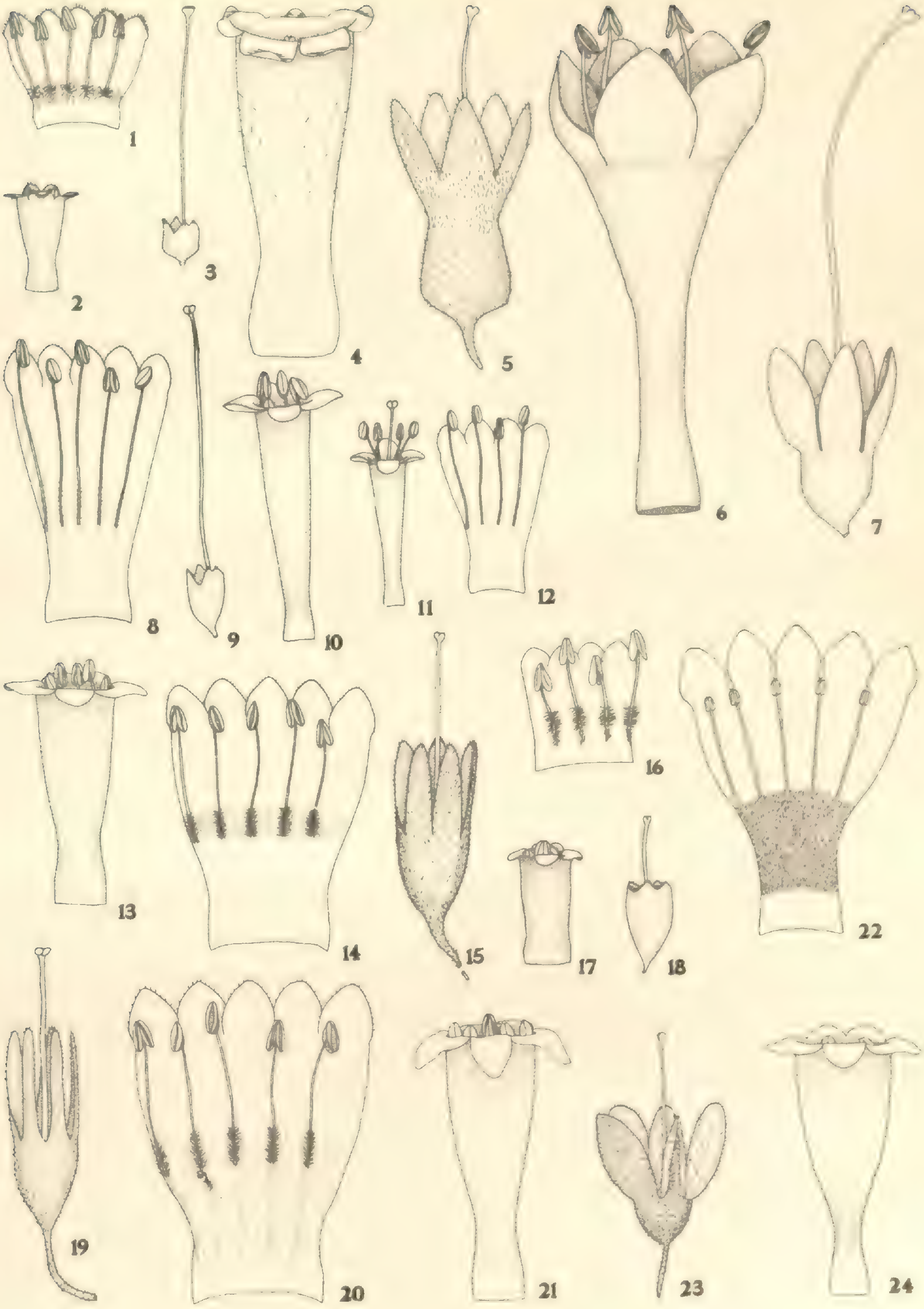
HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

Explanation of Plate

PLATE 18

Figs. 1–3. *Lycium Berlandieri* var. *longistylum* C. L. Hitchcock (pistillate flower).
Figs. 4–5. *Lycium Cooperi* Gray.
Figs. 6–7. *Lycium pallidum* Miers.
Figs. 8–10. *Lycium Andersonii* Gray.
Figs. 11–12. *Lycium Andersonii* var. *Wrightii* Gray.
Figs. 13–15. *Lycium Parishii* Gray.
Figs. 16–18. *Lycium Ameghinoi* Spegazzini.
Figs. 19–21. *Lycium macrodon* Gray.
Figs. 22–24. *Lycium puberulum* Gray.

All figures × 3.



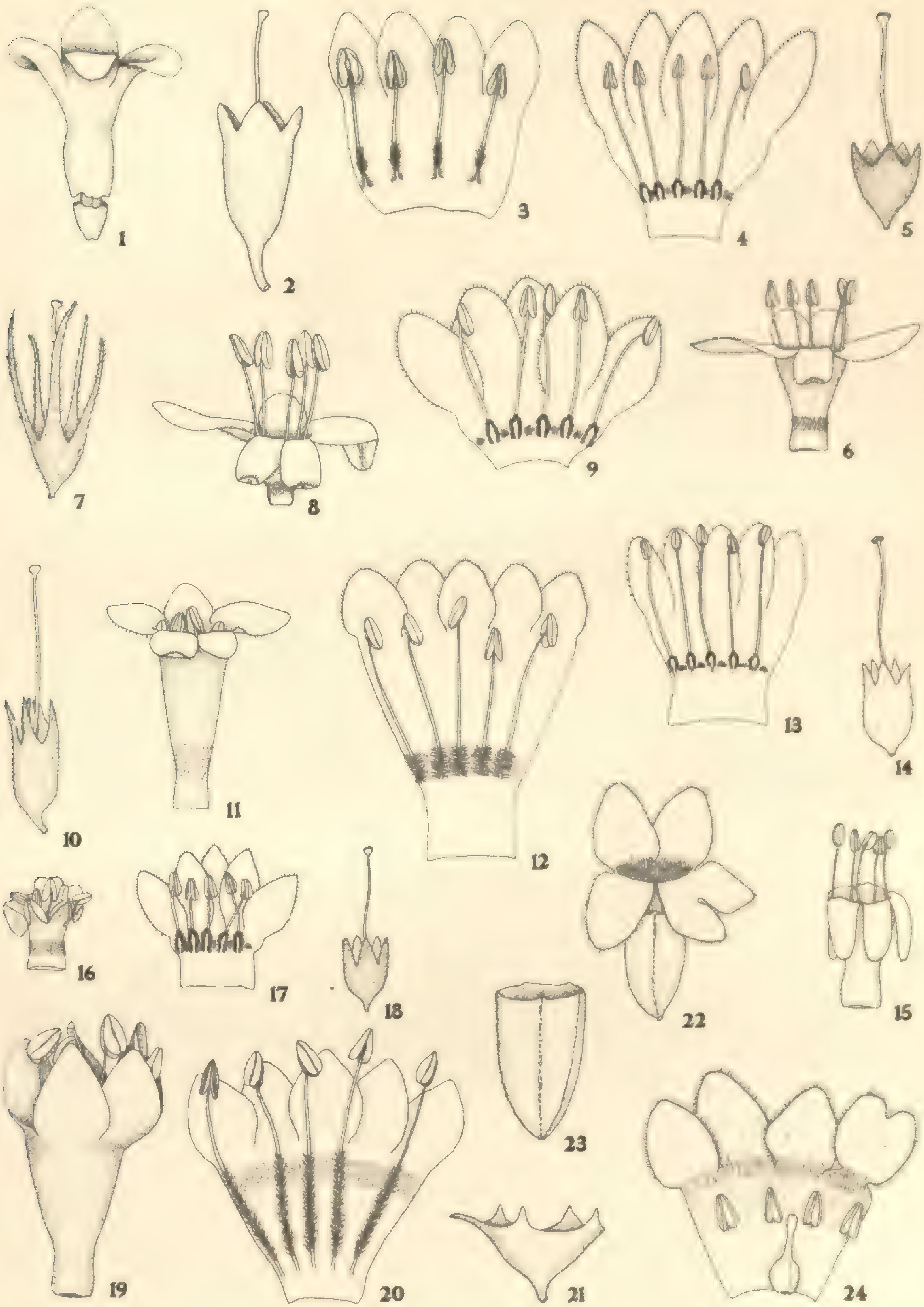
HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

Explanation of Plate

PLATE 19

Figs. 1–3. *Lycium californicum* Nutt. ex Gray.
Figs. 4–6. *Lycium chilense* Miers ex Bertero.
Figs. 7–9. *Lycium ciliatum* Schlechtendahl.
Figs. 10–12. *Lycium ciliatum* × *cestroides.*
Figs. 13–15. *Lycium Comberi* C. L. Hitchcock.
Figs. 16–18. *Lycium Vergarae* Philippi.
Figs. 19–21. *Grabowskia geniculata* (Fernald) C. L. Hitchcock.
Figs. 22–24. *Citharexylum brachyanthum* Gray.

All figures × 3.



HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

PLATE 20

Lycium cyathiformum C. L. Hitchcock. Photograph of the type specimen at the Stockholm Botanical Museum.

HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

Explanation of Plate

PLATE 21

Lycium minimum C. L. Hitchcock. Photograph of the type specimen at the Gray Herbarium.

HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

Explanation of Plate

PLATE 22

Lycium ovalilobum C. L. Hitchcock. Photograph of the type collection at the Missouri Botanical Garden.

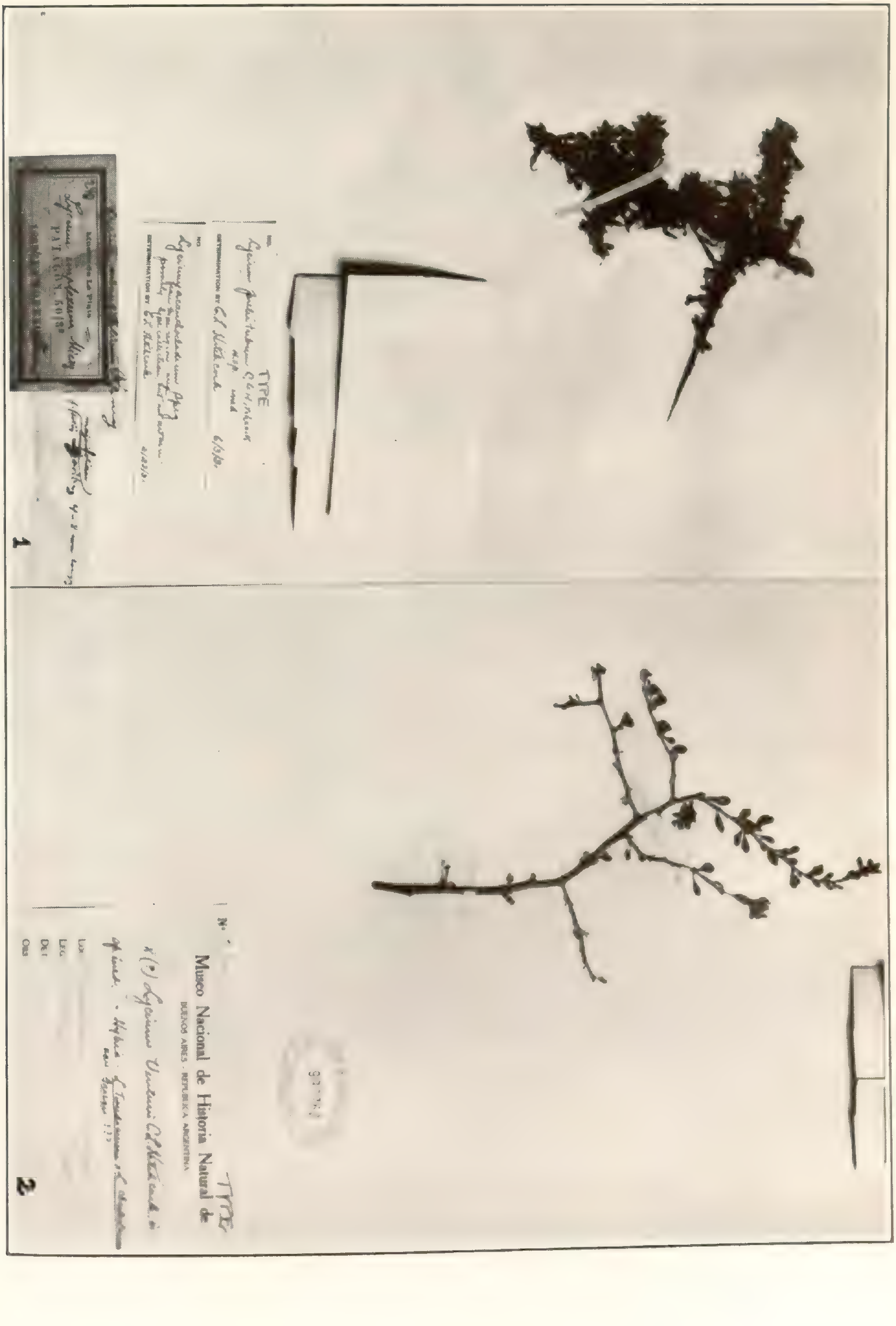
HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

Explanation of Plate

PLATE 23

Fig. 1. *Lycium pubitubum* C. L. Hitchcock. Photograph of the type specimen at the New York Botanical Garden.

Fig. 2. *Lycium Venturii* C. L. Hitchcock. Photograph of the type specimen at the Missouri Botanical Garden.



HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

Explanation of Plate

PLATE 24

Lycium Comberi C. L. Hitchcock. Photograph of the type specimen at Kew.

HITCHCOCK—MONOGRAPH OF THE GENUS LYCIUM

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Annals

of the

Missouri Botanical Garden

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Annals
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Vol. 19 NOVEMBER, 1932 No. 4

NEW OR OTHERWISE NOTEWORTHY APOCYNACEAE OF TROPICAL AMERICA. III[1]

ROBERT E. WOODSON, JR.

Research Assistant, Missouri Botanical Garden
Instructor in Botany, Henry Shaw School of Botany of Washington University

Peltastes Woodson, gen. nov. Apocynacearum (Echitoideae). Calyx majusculis profunde 5-partitus; laciniae foliaceae plus minusve inaequales margine imbricatae intus basi squamas minutas plus minusve numerosas uniforme gerentes. Corolla speciosissima magna infundibuliformis; tubus inferne latiuscule cylindricus dein circa medium inferiusve staminiger et in fauces aut conicas aut tubulatas aut campanulatas late dilatatus numquam constrictus; limbi laciniae 5 aequales oblique obovatae aestivatione dextrorsum convolutae. Stamina 5 omnino inclusa; antherae inter se adglutinatae et stigmati adplicatae anguste sagittatae dorso superne dense hirsutulae basi angustissime 2-auriculatae dimidia parte superiore ventro pollinigerae, sporangiis binis basi in appendiculas rigidas productis, pollinibus granulosis; filamenta ligulata perbrevia laxe pilosula. Ovarii carpella gemina basi distincta apice in stylo gracili producta, ovulis multis in quoque loculo pluriseriatim superpositis; stigma capitato-fusiforme apice obscure bipartitum. Nectarii glandulae 5 saepissime separatae vel basi paulo connatae. Fructus folliculares apocarpi crassiuscule tereti acuminati plus minusve falcati; semina numerosa fusiforme-subscaphoidea apice latiuscule rostrata ibique bene comosa.—Frutices lactescentes volubiles; folia opposita petiolata rigide membranacea vel coriacea eglandulosa peltata. Inflorescentia lateralis vel rarius subterminalis

[1] Issued November 15, 1932.

opposita paniculata rariusve subumbellata, bracteis foliaceis oppositis.

Peltastes peltatus (Vell.) Woodson, comb. nov.
Echites peltata Vell. Fl. Flum. 110. 1830; Icon. **3:** *pl. 32.* 1827.
Stipecoma peltata (Vell.) Miers, Apoc. So. Am. 134. 1878.

Peltastes macrocalyx (Muell.-Arg.) Woodson, comb. nov.
Echites macrocalyx Muell.-Arg. in Martius, Fl. Bras. **6^1:** 160. 1860.
Stipecoma macrocalyx (Muell.-Arg.) Miers, loc. cit. 136. 1878.

Peltastes malvaeflorus Woodson, sp. nov., suffruticosa volubilis; ramis teretibus sat crassis juventate dense et minute ferrugineo-tomentulosis tandem glabratis cortice brunneis lutescentibus rimosis; foliis oppositis petiolatis peltatis rigide membranaceis ovatis vel ovato-oblongis apice abrupte acuminatis basi rotundatis 10–18 cm. longis 6–12 cm. latis supra juventate minute ferrugineo-tomentellis tandem glabratis subtus indumento simili ornatis; petiolis 2.5–4.0 cm. longis ut in folio vestitis; inflorescentiis paniculatis cymosis plus minus fasciculatis; pedunculis foliis ca. dimidia aequantibus 1–9-floris dense ferrugineo-tomentellis; pedicellis 1.5–2.0 cm. longis; bracteis foliaceis anguste oblongis ca. 1 cm. longis; calycis lobis foliaceis anguste oblongis abrupte acuminatis 1.0–1.5 cm. longis sparse ferrugineo-tomentellis; corollae speciosissimae gilvae inferne brunnescentis extus omnino glabrae tubo-proprio late cylindrico 0.75–1.25 cm. longo basi ca. 0.75 cm. diametro metiente ad apicem staminigero ibique abrupte dilatato faucibus campanulatis 2.0–2.5 cm. longis ostio ca. 2 cm. diametro metiente lobis late obovato-dolabriformibus 2.5–3.0 cm. longis patulis; antheris anguste sagittatis ca. 1 cm. longis; ovariis ovoideis ca. 0.4 cm. longis glabris; stigmate 0.2 cm. longo; nectarii glandulis ovoideis ovariis vix aequantibus; folliculis crassiusculis 20–25 cm. longis apice connatis glabris vel minutissime papillatis; seminibus 2.25 cm. longis parte dimidia superiore rostratis como dilute aurantiaco ca. 5 cm. longo.—Brazil: Parana: Valhinos, ad marginem silvae primaevae, Nov. 11, 1910, *P. Dusen 10851* (*in flore:* Mo. Bot. Garden Herbarium, type, Herbarium Mus. Bot. Stockholm, duplicate); Rio Grande

do Sul: Silveira Martina, prope Santa Maria, in silva primaeva, March 6, 1893, *G. A. Malme 690* (*in fructu:* Herbarium Mus. Bot. Stockholm, COTYPE, Mo. Bot. Garden Herbarium, photograph).

This species is apparently widely established, having been collected upon numerous occasions in the Brazilian states of Parana, Sao Paulo, and Rio Grande do Sul, by Dusen, the Regnell Exploration parties of the Botanical Museum at Stockholm, and the botanists of the Expedition der Kaiserlichen Akademie der Wissenschaften in Wien. It differs from the closely related *P. peltatus*, for which it has been mistaken, in the larger corolla, the tube of which about half equals the throat, the proportionally shorter calyx-lobes, and the fewer-flowered inflorescence. The leaves of the latter species are also relatively larger than in *P. malvaeflorus*, and a slightly more coriaceous texture predominates. At present, true *P. peltatus* is known with certainty only from the Brazilian state of Minas Geraes.

Peltastes stemmadeniiflorus Woodson, sp. nov., suffruticosa volubilis; ramis subcompressis sat crassis juventate ferrugineo-tomentulosis maturitate glabratis; foliis oppositis petiolatis peltatis rigide membranaceis late ovatis apice abrupte acuminatis basi rotundatis 18–20 cm. longis 12–15 cm. latis supra glabratis subtus glabratis vel sparse ferrugineo-tomentellis; petiolis 7–9 cm. longis ut in folio vestitis; inflorescentiis paniculatis cymosis lateralibus oppositis; pedunculis petiolis vix dimidio aequantibus dense ferrugineo-tomentulosis ca. 7-floris; pedicellis 1.5 cm. longis ut in pedunculo vestitis; bracteis foliaceis glabratis oblongo-spathulatis pedicello ca. aequantibus; calycis lobis foliaceis late oblongo-spathulatis abrupte acuminatis 1.5–2.0 cm. longis extus glabratis inferne sparse tomentellis; corollae speciosissimae ut videtur flavae extus omnino glabrae tubo-proprio 2.25 cm. longo basi ca. 0.75 cm. diametro metiente faucibus gradatim dilatatis conico-campanulatis 2 cm. longis ostio ca. 1.5 cm. diametro metiente lobis late obovato-dolabriformibus acuminatis 2.0–2.5 cm. longis patulis; genitaliis ignotis; folliculis desiderantur.—PARAGUAY: in altaplanitie et declivibus, Sierra de Amambay, Dec. 1907, *T. Rojas 9838* (Herbarium Mus. Palat. Vindob., TYPE, Mo. Bot. Garden Herbarium, photograph).

The larger calyx-lobes, longer corolla tube-proper, and gradually dilating, conical-campanulate corolla-throat serve to distinguish *P. stemmadeniiflorus* from the neighboring *P. malvaeflorus* of southern Brazil.

Peltastes giganteus Woodson, sp. nov., suffruticosa volubilis; ramis teretiusculis sat crassis juventate ut videntur minute ferrugineo-tomentulosis maturitate certe glabratis; foliis oppositis petiolatis peltatis coriaceis late ovatis apice abrupte et brevissime caudato-acuminatis basi rotundatis 35 cm. longis 20 cm. latis supra subtusque glabratis; petiolo 12 cm. longo glabrato; inflorescentiis plus minusve fasciculatis subumbellatis 4–5-floris; pedunculo minute ferrugineo-tomentello petiolo multo breviore; pedicellis 1 cm. longis ut in pedunculo vestitis; bracteis oblongo-lanceolatis acuminatis pedicellis subaequantibus; calycis lobis foliaceis oblongis abrupte mucronulatis 1.25–1.5 cm. longis extus glabratis inferne sparsissime tomentellis; corollae speciosae ut videtur flavidulae extus omnino glabrae tubo-proprio late cylindrico 2 cm. longo basi ca. 0.5 cm. diametro metiente ad apicem staminigero ibique gradatim dilatato faucibus late tubulatis 2.5 cm. longis ostio ca. 1 cm. diametro metiente lobis late obovatis dolabriformibus 2 cm. longis patulis; antheris anguste sagittatis 1.25 cm. longis; ovariis late ovoideis 0.25 cm. longis dense ferrugineo-tomentellis; stigmate 0.2 cm. longo; nectariis ovoideo-dentiformibus ovariis vix aequantibus; folliculis ignotis.—Bolivia: exact locality and date lacking, *M. Bang 2804* (Mo. Bot. Garden Herbarium, type).

At present the only species of *Peltastes* with a tubular corolla-throat by which it may readily be distinguished as well as by means of the unusually large leaves.

Peltastes colombianus Woodson, sp. nov., suffruticosa volubilis; ramis teretibus crassiusculis juventate minute ferrugineo-puberulis mox glabratis; foliis oppositis longe petiolatis peltatis rigide membranaceis ovatis vel late ovalibus apice abrupte brevissimeque caudato-acuminatis basi rotundatis 18–25 cm. longis 15–20 cm. latis supra minutissime papillatis in umbilico plus minusve ferrugineo-tomentulosis subtus glabris; petiolis 8–10 cm.

longis, juventate minute ferrugineo-tomentellis tandem glabratis; inflorescentiis paniculatis cymosis; pedunculis petiolo paulo brevioribus 10–15-floris minute ferrugineo-tomentellis; pedicellis 1.5–2.0 cm. longis; bracteis oblongo-spathulatis petiolo paulo brevioribus; calycis laciniis late oblongo-spathulatis breviter acuminatis 2.5–3.0 cm. longis basi sparse tomentellis superne glabratis intus multiglandulosis; corollae magnae extus glabrae tubo-proprio latiuscule cylindrico 2.5–2.75 cm. longo basi ca. 0.4 cm. diametro metiente faucibus gradatim dilatatis conicis 1.5 cm. longis ostio ca. 1.5 cm. diametro metiente lobis obovato-orbiculatis ca. 1 cm. longis patulis; antheris anguste sagittatis 1.25 cm. longis; ovariis ovoideis ca. 0.2 cm. longis minute ferrugineo-tomentellis; nectariis ovoideo-dentiformibus ovariis paulo brevioribus; folliculis ignotis.—COLOMBIA: vicinity of Santa Marta, alt. 2000 ft., June, 1899, *H. H. Smith 2412* (Mo. Bot. Garden Herbarium, TYPE).

Approaches *P. macrocalyx*, but differs conspicuously in its much larger, nearly glabrous foliage, its broader calyx-lobes, and its gradually dilating, conical corolla-throat. The latter species, moreover, is apparently confined to southeastern Brazil.

Of the six species referred to the genus *Peltastes* in the paragraphs immediately preceding, *P. peltatus* and *P. macrocalyx* were recognized by Mueller-Argoviensis as belonging to the inclusive genus *Echites*, although he noted in them certain characters in common with his monotypic genus *Stipecoma*, such as the peltate leaves and rostrate seeds. Miers, in 1878, was quick to take advantage of Mueller's observations, and transferred the species mentioned unequivocally to *Stipecoma*.

Although sharing with *Stipecoma* such conspicuous features as peltate leaves, rostrate seeds, and a somewhat similar geographical distribution, *Peltastes* differs in its opposite, lateral inflorescences, infundibuliform corolla, foliaceous bracts and calyx-lobes, exceedingly numerous and indefinitely distributed squamellae, and more robust vegetative habit. The distinction in vegetative habit is further accentuated in a very tangible way by the possession of a conspicuous, ferruginous indument by the six known species of *Peltastes*, since the single species of *Stipecoma* is glabrous in all parts.

Peltastes differs from *Echites* P. Br. in its opposite, lateral inflorescences, infundibuliform corolla, indefinitely distributed squamellae, and peltate leaves. Technical details of the reproductive organs also differ.

Fernaldia brachypharynx Woodson, sp. nov., suffruticosa volubilis; ramis teretibus minute puberulis tandem glabratis; foliis oppositis longiuscule petiolatis membranaceis late ovatis apice subiter acuminatis basi rotundatis 7–10 cm. longis 5–7 cm. latis supra sparse minutissimeque pilosulo-papillatis subtus pallidioribus minute sparseque puberulis; petiolis 1.5–2.0 cm. longis sparse pilosulis; inflorescentiis pseudo-racemosis multifloris; pedunculo minute puberulo petiolo paulo superante; pedicellis prope apicem pedunculi congestis ca. 0.5 cm. longis post maturitatem paulo accrescentibus; bracteis minute ovato-lanceolatis scariaceis 0.1–0.2 cm. longis; calycis laciniis ovatis acuminatis 0.2–0.3 cm. longis extus sparse pilosulis intus basi squama deltoidea margine minute crenulata instructis; corollae speciosae ut videtur albidae extus in alabastro omnino pilosulae tubo-proprio latiuscule cylindrico 1.75–2.0 cm. longo basi ca. 0.3 cm. diametro metiente faucibus anguste conicis 1.5–1.75 cm. longis ostio ca. 0.75 cm. diametro metiente lobis oblique obovatis acuminatis ca. 1.25 cm. longis patulis; antheris oblongo-sagittatis basi obtuse auriculatis 0.6 cm. longis; ovariis oblongoideis ca. 0.15 cm. longis glabris; stigmate fusiformi apice longe-apiculato ca. 0.2 cm. longo; nectario ut in *F. pandurata* lobato ovariis ca. dimidio aequante; folliculis desiderantur.—Guatemala: along the road from Escuintla to the port of San José de Guatemala, Aug. 23, 1860, *S. Hayes s. n.* (Gray Herb., type, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

This striking species may easily be distinguished from *F. pandurata* (A. DC.) Woodson by means of its narrowly conical corolla-throat which about equals in length the broadly cylindrical proper-tube, contrasting sharply with the broadly campanulate throat and much longer, narrower proper-tube of the latter species. The flower-buds of *F. brachypharynx*, moreover, are generally pilosulose without, while those of *F. pandurata* are merely somewhat ciliolate at the tip.

Thenardia tubulifera Woodson, sp. nov., suffruticosa volubilis; ramulis teretibus tenuibus glabris; foliis oppositis breviter petiolatis membranaceis elliptico-lanceolatis apice subcaudato-acuminatis basi obtusis 4–7 cm. longis 1.5–2.5 cm. latis supra glabris subtus in nervo medio venisque laxe pilosulis; petiolis 0.5–1.0 cm. longis minutissime puberulis; inflorescentiis subumbellato-corymbosis pedunculo 2.5–3.0 cm. longo ad apicem trichotomo ramulis 0.5–0.75 cm. longis; pedicellis prope apices ramulorum congestis ca. 2.5 cm. longis post maturitatem paulo accrescentibus glabris; bracteis lanceolatis minutis; calycis laciniis ovatis acutis 0.2 cm. longis extus glabris intus squama deltiforma subintegra ca. 0.75 cm. longa instructis; corollae salverformis haud rotatae tubo late cylindrico prope medium paulo constricto 0.5–0.6 cm. longo basi ca. 0.2 cm. diametro metiente; lobis obovato-orbicularibus breviter oblique apiculatis 0.75 cm. longis patulis; antheris anguste sagittatis 0.7–0.8 cm. longis omnino exsertis; ovariis ovoideis 0.15 cm. longis glabris; stigmate fusiforme apice breviter bipartito ca. 0.125 cm. longo; nectariis late ovoideis integris ovariis vix aequantibus; folliculis ignotis.—MEXICO: Jalisco: exact locality and date lacking, *L. Diquet s. n.* (N. Y. Bot. Garden Herbarium, TYPE, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

Of the general aspect of *Th. floribunda* HBK., but differing from the other known species of the genus in the development of a conspicuous corolla-tube. *Th. tubulifera* may be distinguished from the latter species also in the pubescence of the lower surface of the leaves which occurs generally along the midrib and veins and not merely in small patches in the axils of the midrib.

Echites turrigera Woodson, sp. nov., suffruticosa volubilis; ramulis teretibus gracilibus juventate minute sparseque pilosulis mox glabratis; foliis oppositis longiuscule petiolatis rigidiuscule membranaceis ovato-oblongis apice acuminatis basi obtusis plerisque 3.5–5.0 cm. longis 2.25–3.0 cm. latis maturitate omnino glabris dilute viridibus opacis; petiolis 0.75–1.0 cm. longis; inflorescentiis cymosis lateralibus alternatis 14–20-floris; pedunculo foliis subaequante sparse pilosulo; pedicellis 1.0 cm. longis post maturitatem paulo accrescentibus ut in pedunculo vestitis;

bracteis linearibus 0.2–0.5 cm. longis scariaceis vel parum subfoliaceis; calycis laciniis anguste lanceolatis acuminatis 0.75 cm. longis subfoliaceis extus glabriusculis intus basi squamellas 4–6 dentiformes gerentibus; corollae salverformis colore dilute flavo-viridis tubo gracillimo 2.75 cm. longo basi cylindrico ca. 0.2 cm. diametro metiente paulo infra medium conspicue dilatato ibique staminigero deinde faucem versus sensim attenuato lobis oblique obovatis acuminatis 0.75 cm. longis patulis; antheris anguste sagittatis basi acutissime auriculatis 0.75 cm. longis; ovariis oblongoideis 0.3 cm. longis glabris; nectariis ovoideis compressis ovariis dimidio aequantibus; folliculis ignotis.—GUATEMALA: Gualan, alt. 620 ft., June 20, 1909. *C. C. Deam 6376* (Mo. Bot. Garden Herbarium, TYPE).

The nearest ally of the foregoing is apparently *E. yucatanensis* Millsp., from which it differs in the larger, paler leaves which are not pandurate, the longer, subfoliaceous calyx-lobes, and the more floriferous, more perfectly cymose inflorescence. The specific adjective is in fanciful allusion to the clustered, spire-like floral buds.

Galactophora magnifica Woodson, sp. nov., suffrutescens omnino glabra; caulibus erectis teretibus sat crassis altitudine ignotis; foliis oppositis sessilibus coriaceis late ovato-cordatis apice obtusis basi amplexicaulibus 4.5–5.0 cm. longis 3.0–3.5 cm. latis subtus pallidis margine in sicco subrevolutis; inflorescentiis terminalibus ca. trifloris; pedunculo quam folio multo breviore; pedicellis 1 cm. longis; bracteis minutis vix bene visis; calycis laciniis ovato-lanceolatis acuminatis 2.0–2.5 cm. longis 0.75–1.0 cm. latis scariaceis vel parum petaloideis extus glabris intus basi squamellas minimas extra-axillares gerentibus; corollae speciosissimae infundibuliformis (colore aut roseae aut dilute flavidulae?) tubo-proprio breviuscule cylindrico 2.0-2.25 cm. longo basi ca. 0.4 cm. diametro metiente ad apicem staminigero ibique dilatato faucibus late campanulatis 3 cm. longis ca. 2.5 cm. diametro metiente lobis late ovatis breviter acuminatis 4.5 cm. longis patulis patentibusve; antheris anguste lanceolatis 0.8 cm. longis basi acute biauriculatis dorso glabriusculis; nectario cupuliformi plus minusve crenulato ca. 0.1 cm. alto ovariis oblongoideis gla-

bris ca. ⅓ aequante; folliculis ignotis.—BRAZIL: Procedencia Juruena, "campo humido e pantuoso," April, 1909. *F. C. Hoehne 1759* (U. S. National Herbarium, TYPE, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

This species is probably the most striking of the genus *Galactophora* known at present. Like *G. calycina* (Hub.) Woodson, it is without the peculiar aculeolate glands which characterize the exterior of the corolla, calyx, and stems of the other species, but it differs from the latter in the large, ovate leaves, and particularly in the much larger corolla with showy, spreading lobes.

Temnadenia ornata (Hoehne) Woodson, comb. nov.

Echites ornata Hoehne, Comm. Linh. Telegr. Estrat. Matto Grosso, Annexo 5, Bot. **6**: 82. *pls. 120, 131, fig. 1.* 1915.

The genus *Temnadenia,* as established by Miers, Apoc. So. Am. 207, 1878, is an extremely unnatural conglomeration of twenty-two species of widely separate affinities. Of those originally transferred to the genus, one species is more correctly included within the genus *Tabernaemontana* L., one within *Dipladenia* A. DC., eight within *Mandevilla* Lindl., and eight within *Prestonia* R. Br. The remaining four constitute a fairly natural entity to which Miers's generic name must be applied. *Temnadenia,* as thus restricted, is found to be a genus very closely related to *Echites* P. Br., differing chiefly in its di- or trichotomous, indeterminate inflorescence and structural details of the reproductive organs. The flowers of *Echites* are always pale greenish-yellow, while those of *Temnadenia* are a rich cream suffused with pink, or in one species, *T. violacea* (Vell.) Miers, a nearly uniform, rich crimson gradually paling toward the base of the corolla-tube. The geographical distribution of the two genera also differs, that of the former being limited to the Greater Antilles, the Bahama Islands, southern Florida, Yucatan, and Guatemala, and that of the latter to southern Brazil.

Mandevilla sertuligera Woodson, sp. nov., suffruticosa volubilis; ramulis gracillimis teretibus juventate minute hispidulis puberulisve tandem glabratis maturitate rubidulis parum rimosis; foliis oppositis petiolatis membranaceis elliptico-ovatis acumi-

natis obscure cordatis plerisque 6–8 cm. longis 3.0–3.5 cm. latis supra hispidulo-strigillosis subtus dense lanato-tomentulosis; petiolis 0.75–1.25 cm. longis ut in ramulis vestitis; squamis stipulaceis haud visis; inflorescentiis racemosis corymbosis lateralibus alternatis vel subterminalibus multifloris; pedunculo foliis ca. dimidio breviore hispidulo; pedicellis congestis subsecundis 0.3–0.4 cm. longis post maturitatem paulo accrescentibus; bracteis linearibus pedicellis subaequantibus scariaceis; calycis lobis anguste lanceolatis longe acuminatis subsetaceis 0.4–0.6 cm. longis scariaceis extus pilosulis intus basi squamellas multas denticuliformes uniforme gerentibus; corollae tubiformis dilute flavidulae tubo cylindrico 0.75 cm. longo basi ca. 0.2 cm. diametro metiente infra medium staminigero faucibus paulo ampliatis lobis late ovatis acutiusculis erectis 0.3–0.4 cm. longis; antheris anguste oblongis 0.4 cm. longis basi obscure auriculatis; ovariis ovoideis minute puberulo-papillatis in stylo abrupte contractis 0.15 cm. longis; nectarii glandulis oblongo-ovoideis basi connatis ovariis paulo superantibus; folliculis ignotis.—Mexico: Michoacan: rocky hills near Coru Station, alt. 6000 ft., Jan. 23, 1907. *C. G. Pringle 13890* (U. S. National Herbarium, type, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

Most closely related to *M. Syrinx* Woodson, from which it differs in its shortly pedunculate, corymbose inflorescence and extremely long-attenuate or subsetaceous calyx-lobes which are nearly twice as long as in the latter species. In addition to the type specimen, the species is represented in several of the leading herbaria of America and Europe by two other collections by Pringle in the Mexican states of Michoacan and Morelos.

Mandevilla rugosa (Benth.) Woodson, comb. nov.

Echites rugosa Benth. in Hook. Journ. Bot. **3**: 249. 1841.

Amblyanthera versicolor (Stadelm.) Muell.-Arg. *β. intermedia* Muell.-Arg. in Mart. Fl. Bras. **6**[1]: 146. 1860, in part.

Mitozus rugosus (Benth.) Miers, Apoc. So. Am. 222. 1878.

This member of the puzzling *mollissima-scabra* complex differs from the latter species chiefly in the coriaceous or subcoriaceous, strikingly rugose foliage.

Mandevilla rutila Woodson, sp. nov., suffruticosa volubilis; ramulis gracillimis juventate ferrugineo-pilosulis tandem glabratis; foliis oppositis breviter petiolatis membranaceis late ellipticis acuminatis obscure auriculatis 8–15 cm. longis 3–5 cm. latis supra minute ferrugineo-pilosulis nervo medio parce glanduligeris subtus dilute ferrugineo-pilosulis; petiolis 0.5–1.0 cm. longis sparse pilosulis; squamis stipulaceis obsoletis vel minus manifestis; racemis simplicibus lateralibus alternatis pedunculo foliis saepissime aequale multifloro; pedicellis 0.3–0.5 cm. longis maturitate parum accrescentibus; bracteis linearibus filiformibusve ca. 1 cm. longis scariaceis; calycis laciniis ovato-lanceolatis longeacuminatis 0.2–0.4 cm. longis scariaceis basi intus squamellam deltatam oppositam gerentibus; corollae infundibuliformis fulvo-aurantiacae extus sparse pilosulae tubo-proprio anguste cylindrico superne parum gibboso 1.75–2.25 cm. longo basi ca. 0.15 cm. diametro metiente faucibus conicis 1.0–1.5 cm. longis ostio ca. 0.75–1.0 cm. diametro metiente lobis oblique obovatis acuminatis 1.25–1.75 cm. longis patulis; antheris anguste ellipticis obscure auriculatis 0.4 cm. longis; ovariis ovoideis in stylo gracili gradatim productis 0.15 cm. longis glabris; stigmate 0.2 cm. longo breviter apiculato; nectariis 5 oblongoideis ovariis subaequantibus; folliculis gracillimis conspicue articulatis 15–20 cm. longis glabris; seminibus 0.5 cm. longis como aurantiaco ca. 2 cm. longo.—Bolivia: La Paz: Mapiri, alt. 5000 ft., April, 1886. *H. H. Rusby 2385* (N. Y. Bot. Garden Herbarium, TYPE, Mo. Bot. Garden Herbarium, photograph and analytical drawings).

Most closely related to *M. scabra* (R. & S.) K. Sch., from which it may be distinguished by means of its much longer, linear to filiform bracts, pale-ferruginous foliar indument, and longer, more attenuate calyx-lobes. At present five different collections of *M. rutila* are known, all from the province of La Paz, Bolivia. *M. scabra* is apparently confined to Venezuela, the Guianas, and northern Brazil.

Secondatia Macnabii (Urb.) Woodson, comb. nov.

Orthechites Macnabii Urb. Symb. Ant. 6: 37. 1909.

The monotypic genus *Orthechites* is distinguishable from *Secondatia* A. DC. merely by a slight constriction of the corolla-

tube at the insertion of the stamens, and by lanceolate calyx-lobes. In all other essential respects, the two genera are quite conformable and surely appear to constitute a natural unity. No one as yet has proposed the establishment of a segregate genus upon the basis of the glabrous anthers of *S. peruviana* Poeppig or the lateral cymes of *S. Schlimiana* Muell.-Arg. and *S. floribunda* A. DC., and the distinguishing characteristics of *S. Macnabii* likewise appear to be merely specific, or at most sectional, in nature. Since *S. Macnabii* is apparently confined to Jamaica, the genus *Secondatia* is found to have a type of geographical distribution somewhat similar to that of *Mandevilla* Lindl. subgen. *Eumandevilla.*

Odontadenia laxiflora (Rusby) Woodson, comb. nov.

Laubertia (?) *laxiflora* Rusby, Bull. N. Y. Bot. Gard. **4:** 408. 1907.

A species superficially differing from others of *Odontadenia* Benth. in the somewhat smaller flowers, but evidently congeneric in all other essential particulars. The characters of *Odontadenia* must be rather liberally interpreted unless such segregate genera as *Anisolobus* A. DC. and *Perictenia* Miers are to be regarded as valid. The distinguishing characters of the little-understood genus *Laubertia* A. DC. have been briefly discussed in a previous note of this series (Ann. Mo. Bot. Gard. **18:** 556. 1931).

Mesechites minima (Britton & Wilson) Woodson, comb. nov.

Echites minima Britton & Wilson, Mem. Torrey Bot. Club **16:** 94. 1920.

A most appropriately named species indigenous to central and southern Cuba, a range shared by its only Cuban congener, the familiar, showy-flowered *M. myrtifolia* (R. & S.) Muell.-Arg. (= *Echites rosea* A. DC.).

In restoring at this time the genus *Mesechites* Muell.-Arg. which has been in disuse since 1878, only a few words are necessary in justification. From *Echites* P. Br. (in the stricter sense as typified by *E. umbellata* Jacq.), with which it is still confused, *Mesechites* may readily be distinguished by its glandular foliage, dichotomous, bostrychoidally racemose inflorescence, obscurely

auriculate anthers, and multiglandular calyx. Although persistently confounded with *Echites, Mesechites* is more naturally to be associated with *Mandevilla* Lindl., from which it is quite easily separable because of its dichotomous bostrychoid inflorescence and fusiform stigma. The foliar glands of most species of *Mesechites* also are quite distinctive, usually being more or less laminate in form and clustered concentrically at the very base of the midrib, conditions never observed among species of *Mandevilla.*

Mesechites bicorniculata (Rusby) Woodson, comb. nov.

Echites bicorniculata Rusby, Descr. So. Am. Pl. 86. 1920.

Differing from the closely related *M. trifida* (Jacq.) Muell.-Arg. chiefly in the possession of a conspicuous vegetative indument.

Mesechites Sanctae-Crucis (S. Moore) Woodson, comb. nov.

Echites Sanctae-Crucis S. Moore, Trans. Linn. Soc. Bot. III. **4:** 396. 1895.

Echites trifida Jacq. var. *Sanctae-Crucis* (S. Moore) Malme, Bull. Herb. Boiss. II. **4:** 196. 1904.

Apparently deserving of specific rank because of its shorter corolla-lobes, exappendiculate nodes, and comparatively restricted, more southerly distribution (Paraguay, adjacent Bolivia, Argentina, and Brazil), by which it may be distinguished from *M. trifida* (Jacq.) Muell.-Arg.

Mesechites citrifolia (HBK.) Woodson, comb. nov.

Echites citrifolia HBK. Nov. Gen. **3:** 216. 1818.

Echites brevipes Benth. Pl. Hartw. 216. 1849.

Mesechites brevipes (Benth.) Muell.-Arg. Linnaea **30:** 454. 1860.

Mitozus brevipes (Benth.) Miers, Apoc. So. Am. 223. 1878.

A comparison of the type specimen of *E. citrifolia* (*Humboldt & Bonpland s. n.* in Hb. Mus. Hist. Nat. Paris) with that of *E. brevipes* (*Hartweg 1195* in Hb. Brit. Mus.) permits no doubt concerning the necessity of this combination. Photographs of either specimen are deposited in the herbarium of the Missouri Botanical Garden.

SOME NEW SPERMATOPHYTES FROM TEXAS[1]

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In a collection of plants made by Mr. John A. Moore and the writer from the mountains of western Texas during the summer of 1931 several new species and one new variety were discovered.

Cladothrix lanuginosa Nutt. var. **carnosa** Steyermark, n. var.

Caulibus usque ad ramulos floriferos glabrescentibus; foliis caulinis involucralibusque parvis, 4–13 mm. longis, 3–9 mm. latis, carnosis, caulinis omnibusque praeter involucralibus supremis glabrescentibus. (Gravelly flat, 3 mi. east of Study Butte, Brewster Co., Texas, alt. 762 m., June 26, 1931, *Moore & Steyermark 3795.*—TYPE, in Gray Herb.).

Stems, up to the floriferous branchlets, glabrescent; cauline and involucral leaves small, 4–13 mm. long, 3–9 mm. broad, fleshy, the cauline and all except the uppermost involucral leaves glabrescent.

This variety is distinguished from *Cladothrix lanuginosa* by its stem being glabrescent up to the floriferous branches, instead of pubescent throughout, by its fleshy, instead of soft membranaceous, cauline and involucral leaves, and by its cauline and all except the uppermost involucral leaves being glabrescent instead of stellate-pubescent. The uppermost involucral leaves in the species are densely and conspicuously stellate-pubescent, producing a white cottony appearance at the summit of the inflorescence, whereas in the variety the pubescence is inconspicuous and does not produce the cottony effect. The leaves of the variety are on the whole smaller than those of the species.

The variety was found growing in abundance in an arid gypsum flat several miles north of the Rio Grande in soil heavily impregnated with alkaline salts, in association with such calciphiles as *Atriplex canescens, A. acanthocarpa, Suaeda suffrutescens, Greggia camporum,* and *Nama Havardii.* The extremely alkaline soil here has probably been a leading factor in producing the fleshy-leaved condition.

[1] Issued November 15, 1932.

To this variety should be referred Havard's no. 104 collected around Tornillo Creek, western Texas (Gray Herb.), a locality about thirty miles east of the one from which the present collection was made.

Polygala rimulicola Steyermark, n. sp.

Perennis tenuis e basi lignosa; caulibus multis, 1–5 cm. longis, ramosis, prostratis vel parum ascendentibus, gracillimis, confertim foliosis, viridibus, glabris sub lente papillis plurimis minutis et pilis brevissimis, mollibus sparsis incurvatis, obsitis; foliis omnino similibus, parum carnosis, glabris sub lente minute papillosis sparseque puberulentibus, elliptico-ovatis, acutis vel parum cuspidatis, subsessilibus, 1.5–4 mm. longis, 1–2.5 mm. latis; floribus 1–2, terminalibus, 5 mm. longis; pedicellis maturitate recurvatis nutantibusque, ca. 2 mm. longis; sepalo superiore ovato, acuto, glabro, persistente, roseo-purpurascenti alboque, 1.5–2 mm. longo, 1 mm. lato; sepalis inferioribus libris, oblongo-obovatis, acutis, deciduis, glabris, roseo-purpurascentibus albisque, 2–3 mm. longis, 1 mm. latis; alis roseo-purpurascentibus albisque, deciduis, obliquis, late obovatis, apice obtusis, basi angustatis, venosis, glabris, 4 mm. longis, 2.5 mm. latis; carina ca. 3 mm. longa, subviridi-flava, e rostrata, inflata, saccata, apice suboblique truncata angulis rotundatis basi superiore, appendicibus duobus brevibus parallelis rectis ornata, ad basim floris adversis, tertia parte superiore pilis plurimis brevibus erectis tenuibus tecta; petalis superioribus basi albis, apice purpureis, longitudine $\frac{3}{8}$ carinam adnatis, lineari-oblongis, apice subtruncato, intus pilis paucis brevibus tecto, 4.5 mm. longis, ca. 1 mm. latis, staminibus 7; capsula late obovato-ovata, emarginata, venosa, parce pilis brevibus incurvatis tecta, dense pilosa in sino apicis emarginatae, ca. 2 mm. longa, 1.5–2 mm. lata; semine oblongo, dense sericeo-pubescente pilis longis, 1–1.5 mm. longo; arillo 0.5 mm. longo, glabro, corneo, globoso, latere utraque umbone magno ornato. (Exposed rock crevices, Smith Canyon, Guadalupe Mts., Culberson Co., Texas, alt. 1900 m., July 20, 1931, *Moore & Steyermark 3515.*—TYPE, in Gray Herb.).

A delicate perennial from a woody base; stems numerous, very slender, prostrate or slightly ascending, branching, 1–5 cm. long,

green, apparently glabrous but under high magnification covered with numerous minute papillae and short soft scattered incurved hairs; leaves similar throughout, subsessile, elliptic-ovate, 1.5–4 mm. long, 1–2.5 mm. broad, acute to slightly cuspidate, slightly fleshy, apparently glabrous, but under high magnification covered with numerous minute papillae and few short soft scattered hairs; flowers 1–2, terminal, 5 mm. long; pedicels at maturity recurved and nodding, 2 mm. long; upper sepal persistent, rose-purplish and white, ovate, 1.5–2 mm. long, 1 mm. broad, acute, glabrous; lower sepals free, deciduous, rose-purplish and white, oblong-obovate, 2–3 mm. long, 1 mm. broad, acute, glabrous; wings deciduous, rose-purplish and white, oblique, broadly obovate, 4 mm. long, 2.5 mm. broad, obtuse at apex, narrowed at base, veiny (the veins ending free), glabrous; keel unbeaked, inflated, greenish-yellow, pouch-shaped, 3 mm. long, the outer upper and lower ends rounded, the inner upper end terminating in 2 short parallel straight appendages extending towards the base of the flower, the upper third of the keel covered with numerous erect short fine hairs; upper petals united to the keel about 3/8 their length, white at the base, purplish-red at the apex, linear-oblong, 4.5 mm. long, 1 mm. broad, subtruncate at the apex, slightly puberulent within; stamens 7; capsule venose, broadly obovate-oval, 2 mm. long, 1.5–2 mm. broad, emarginate, sparingly covered with short incurved hairs, densely pubescent in the sinus of the emarginate apex; seed oblong, 1–1.5 mm. long, densely sericeous-pubescent with long hairs; aril globose, 0.5 mm. high, with a large umbo at each side, corneous, glabrous.

A well-marked species occurring in crevices of shaded to slightly exposed limestone boulders or cliff-faces in moist ravines of the Guadalupe Mountains.

The combination of characters distinguishing this species are the glabrous globose aril with no conspicuous lobes, the unbeaked keel, persistent upper sepal, prostrate habit, minute leaves and flowers, and essentially glabrous condition of stem, leaves, and fruit.

In habit this species slightly approaches *Polygala macradenia*, but the latter has a pubescent umbo, a 3-plicated beaked keel, thickly gland-dotted leaves, sepals, and fruit, and erect to ascending, instead of prostrate, stems.

It is related to *Polygala acanthoclada*, which it resembles in the beakless keel, and to *P. eucosma*, to which it is more closely allied. The Mexican *P. Purpusii*, *P. Conzattii*, and *P. Parryi*, with their glabrous arils, persistent upper sepals, unbeaked keels, and deciduous lower sepals, also are closely allied to this species, but, as Dr. S. F. Blake observes, the seed of *P. rimulicola* is unique in its group.

Laphamia quinqueflora Steyermark, n. sp.

Perennis humilis multum ramosus effuse patulus e caudice robusto lignoso, caespitem confertum formans; caulibus erectis, divaricate corymbifereque ramosis, teretibus, striatis, minute puberulentibus, pullo-viridibus, 1–1.4 dm. altis; petiolis 0.8–1.3 cm. longis, minute puberulentibus; laminis late subrotundato-ovatis aut suborbiculatis, pullo-olivaceo-viridibus, nitidis, membranaceis, oppositis, integris vel leviter repandis, glabris vel pilis paucis sparsis minutis obsitis, obtusis, apice rotundatis, 0.5–1.5 cm. longis, 0.5–2 cm. latis; capitulis eligulatis, multis, 7 mm. longis, ca. 4 mm. latis, plerumque ca. quinque floribus, terminalibus, solitariis, corymbose dispositis; involucri bracteis 5, 2-seriatis, aequalibus, lineari-oblongis, obtusis, carinatis, carina convexa, apice leviter incurvato, 6–7 mm. longis, 1–1.5 mm. latis, moderatim minuteque puberulentibus; disci corollis 4.5–5 mm. longis, limbo cylindraceo subito in tubulum angustum angustato, limbo ca. duplo longiore quam tubulo, minute puberulente; pappo 22–26 aristis inaequalibus setosis barbellulatis, 12–14 brevioribus 10–12 longioribus composito, aristis longissimis, ca. 2 mm. longis, corollae tubulum angustatum, vix excedentibus; achaenio compresso, oblongo-cuneato, basi, paullo angustato, apice truncato, stramineo vel fulvo, hirtello, faciebus medio 1-nervatis. (Niches in exposed limestone cliffs, Lower McKittrick Canyon, Guadalupe Mts., Culberson Co., Texas, alt. 1900 m., July 20, 1931, *Moore & Steyermark 3547*.—TYPE, in Gray Herb.).

A low much-branched, diffusely spreading perennial from a stout woody caudex, forming a dense mat, 1–1.4 dm. high; stems numerous, slender, erect, terete, divergently and corymbosely branched, striate, minutely puberulent, dark green; petioles minutely puberulent, 0.8–1.3 cm. long; blades opposite, broadly

subrotund-ovate or suborbicular, 0.5–1.5 cm. long, 0.5–2 cm. broad, entire or slightly repand, obtuse and rounded at apex, membranaceous, essentially glabrous, dark olive-green, lustrous; heads discoid, numerous, terminal, corymbosely clustered, mostly 5-flowered, 7 mm. long, 4 mm. broad; involucral bracts 5, in 2 series, equal, linear-oblong, 6–7 mm. long, 1–1.5 mm. broad, obtusish, carinate with a convex keel, apex slightly incurved, margins subscarious, convex and slightly incurved, moderately and minutely puberulent; disk-corollas 4.5–5 mm. long, the cylindrical throat abruptly contracted into a narrow tube, the throat about 1¾ times as long as the tube, minutely puberulent; pappus of 22–26 unequal setose barbellate awns, consisting of 10–12 medium to long awns associated with 12–14 shorter ones, the longest awns 2 mm. long, slightly surpassing the constricted corolla-tube; achene compressed, oblong-cuneate, truncate at apex, hirtellous, stramineous to light brown, the faces 1-nerved in the middle.

A very distinct and well-marked species, differing from any of the other species in the genus. In having a pappus of 20 or more unequal rigid hispidulous bristles and a corolla with short proper tube and cylindraceous throat, it properly belongs in the section *Pappothrix*, but differs from the other species in that section especially in having the heads usually 5-flowered. Its distinctive characters are the 5-flowered heads, each of 5 involucral bracts, the essentially glabrous, membranaceous, subrotund, mostly entire or slightly repand leaves, and the pappus of 22 to 26 unequal setose hispidulous bristles.

This species was found growing on vertical exposed moist faces of limestone cliffs in deep canyons at an elevation of 1900–2590 meters (6000–8500 ft.), where it was conspicuous in dense hemispherical clumps, with its lustrous, dark olive-green leaves.

Valeriana texana Steyermark, n. sp.

Perennis caudice denso rugoso multum ramoso; caulibus pluribus, erectis, 1–1.5 dm. altis, gracilibus, fere glabris; foliis radicalibus multis, oblanceolatis vel obovatis, in petiolum longum gracilem paullo alatum contractis, petiolis inclusis, 4–10 cm. longis, 0.6–1.8 cm. latis, glabris, obtusis, integris, longitudine

usque ad ⅔ altitudinem caulis attingentibus; foliis caulinis 1–2 jugis, omnibus simplicibus, oblanceolatis, plerumque brevioribus quam radicalibus, 1–4.5 cm. longis, lobis lateralibus nullis, integris; inflorescentia cyma thyrsiformi composita, multiflora, anthesi valde contracta, pedunculis superioribus oppositis, inferioribus alternatis; floribus parvis, subflavo-albis, multis; corolla 5.5 mm. longa, cum tubo infundibuliformi; staminibus 3, inclusis; fructu oblongo, in apicem truncatum paullo angustato, 3–3.5 mm. longo., prope 1.5 mm. lato, glabro. (On boulders in creek, Upper McKittrick Canyon, Guadalupe Mts., Culberson Co., Texas, alt. 2000 m., July 21, 1931, *Moore & Steyermark 3528*.—TYPE, in Gray Herb.).

Perennial from a thick rugose much-branched ligneous rootstock, 1–1.5 dm. high; stems several, slender, erect, with 1–2 pairs of cauline leaves, essentially glabrous; basal leaves numerous, contracted into a long slender slightly margined petiole, ⅔ the height of the stems, 4–10 cm. long, 0.6–1.8 cm. broad, oblanceolate to obovate, entire, obtusish, glabrous, light green; cauline leaves in 1–2 pairs, all simple, lateral lobes absent, oblanceolate, much shorter than the radical ones, 1–4.5 cm. long, entire; inflorescence a compound thyrsiform cyme, numerously flowered, much contracted at anthesis, the upper peduncles opposite, the lower alternate; flowers small, very numerous, yellowish-white; corolla 5.5 mm. long, the infundibuliform tube 3 times as long as the broadly ovate lobes; stamens 3, included; fruit compressed, oblong, 3–3.5 mm. long, 1.5 mm. broad, slightly narrowed towards the truncate apex, glabrous.

This is the first collection of a species of *Valeriana* from Texas, so far as the writer is aware. It was found on moist shaded limestone cliffs in the ravines of various canyons in the Guadalupe Mountains of Texas, growing at an altitude of 1828–2438 meters (6000–8000 ft.).

It differs strikingly from other North American species of this genus, especially in having the leaves simple and undivided throughout, in the inflorescence much contracted into a compound thyrsiform cyme the length of which averages about one-half that of the flowering stem, and in a strongly developed multicipital caudex. Only *Valeriana pubicarpa* and *V. wyomingensis*

approach this new species. From the former it may be distinguished by the thyrsiform, instead of corymbiform or subcapitate, inflorescence, by the glabrous stems and fruit, and by the simple cauline leaves throughout. From the latter it differs in its strongly developed ligneous caudex, many-flowered contracted inflorescence, instead of a few-flowered, loose and open type, and in its longer corolla which is infundibuliform instead of campanulate.

COCCIDIOIDAL GRANULOMA: A CLASSIFICATION OF THE CAUSATIVE AGENT, COCCIDIOIDES IMMITIS[1]

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History

The purpose of this paper, as the title indicates, is to attempt a proper determination in the classification of fungi of the agent responsible for the disease clinically known by various names, as "blastomycosis" (Montgomery and Ormsby, '08), "oidiomycosis" (Giltner, '18, Ricketts, '01), "protozoic dermatitis" (Montgomery, '00), "dermatitis coccidioides" (Montgomery, Ryfkogel and Morrow, '03, Wolbach, '04), "blastomycetic dermatitis," "coccidioidal granuloma," and the "California disease." Of this list, coccidioidal granuloma has the most widespread acceptance, and in all references in this paper to the pathologic, clinical, or other diagnostic features of the fungus, this term will be used.

Since the report of the first case by Wernicke ('92) there have been 286 cases recorded, and with the one involved in this paper the total now is 287. The disease has received a great deal of attention because of its mode of infection, complicated diagnosis, lack of definitely demonstrable prophylactic measures, great percentage of fatality, peculiar pathogenic abilities, and last, but not least, the indefinite classification of the fungus itself.

In order to present a clearer perspective of the field, a résumé of the noteworthy points involved would be in order.

As stated above, the first case was reported by Wernicke ('92) from Buenos Aires. Clinically, the case was diagnosed as "mycosis fungoides." During the examination spherical organisms resembling protozoa were found in the lesions, and the cause of the disease was considered due to these bodies. Later reports showed that the patient had died of a general infection.

The second case was reported by Rixford in a brief note in the 'Occidental Medical Times' of 1894, later published with Gilchrist in 'Johns Hopkins Hosp. Repts.' ('96). Six months later in the same year, in conjunction with Thorne, he reported another

[1] Issued November 15, 1932.

case in the latter journal. In these two cases, the round organisms were seen in the smears made from the lesions, especially the purulent exudate. Various stages in the development were observed, some smears being filled with difficultly stained, irregular masses of material and some with a highly refractile, clear, non-staining capsule surrounding a group of spores formed endogenously, and stages between the two.

Pathologically, the condition was perplexing inasmuch as it simulated tuberculosis in all its clinical entities. Histological sections showed giant cell formation in the tissue with several of these round growths present.

Treatment with potassium iodide given internally in maximum doses, mercury in the form of protiodide, Fowler's solution with arsenic in gradually increasing doses up to tolerance, gave no beneficial prophylaxis. The various local antiseptics, as iodine, carbolic acid, bromine, bichloride of mercury, and several others, were applied externally, and some were injected into the lesion hypodermically but with no apparent relief. Both patients died.

In 1894 there were only two men in San Francisco who were equipped to do any bacteriological work, S. M. Mouser and Douglas W. Montgomery. The latter was called in on these cases, but could reach no definite conclusion as to the nature of these organisms. The consensus of opinion seemed to point to their being protozoa because of their resemblance to coccidia which cause the disease in rabbits and fowl known as "coccidiosis."

To determine the organism, some material was sent to W. H. Welch, of Johns Hopkins. Expressing doubt as to their protozoological nature, he turned the cultures over to T. C. Gilchrist, of the dermatology department, who had been working on blastomycosis, the lesion of which simulated those of the two cases noticed by Rixford and Thorne. Being unable, in turn, to determine the peculiar growths, he called in Stiles of Washington, an eminent medical zoologist and authority on protozoa. Perplexed as to this puzzling situation, Stiles named them "coccidioides" because of their similarity to the above-mentioned coccidia. Thus the organism from the first case he called *Coccidioides immitis* and that from the second, *Coccidioides pyogenes*.

Following this work, in which an appeal was made for reports

of similar cases, there was nothing additional until Posadas ('00) reported a case and Ophüls and Moffit, in conjunction with Ash (Phila. Med. Jour. 5: 1471, June 30, 1900), in the San Francisco Hospital, reported another. The three latter authors were able to show that on artificial substrates the organism grew out into long mycelia, like a typical fungus of the ordinary mold group. They could thus demonstrate that there were two dissimilar life-cycles present: one in the body of the individual having the spherical forms noted previously, and the other being the filamentous growth present on cultural media. It must be added, however, that Montgomery ('00) had formerly noticed the mold-like development on the cultures he had studied, but, believing them contaminations, had discarded the growths.

From this time on, various attempts were made to study the life history of the fungus, and of these the work of S. B. Wolbach ('04) is outstanding. For this particular point in the paper, however, it suffices to say that the organism has been sufficiently studied and investigated clinically, to arrive at a clearer understanding as to its recognition. There is still much work to be done as to its various other phases.

Etiology and Symptomatology of Coccidioidal granuloma

Coccidioidal granuloma, as a disease, belongs in the class of infectious granulomas. Its course may be exceedingly acute and end fatally in a few weeks, or the agony may be prolonged and a period of several years may elapse before death. Then again, the time may be long and drawn out, with slight pain, as is apparent in the case to be mentioned here. Between the two extremes of time, however, there is a sub-acute type which is neither rapidly fatal nor unduly prolonged in its progress, but which is characterized by a definite and positive tendency to widespread dissemination in the patient, with remissions and relapses, and in which the sufferer lives from a period of six months to two years after infection.

There are many clinical types involved in the disease, and in 1905 Ophüls classified three:

1. Primary cutaneous lesions and later generalization;
2. Primary pulmonary lesions and later generalization, but no skin lesions;

3. Primary pulmonary lesions and secondary subcutaneous lesions.

Many years later, Jacobson ('30) added three other clinical types, and with the addition of two more reported in the literature the total is eight:

4. Primary pelvic involvement without any skin lesions;
5. Primary meningeal or spinal cord involvement without any cutaneous or other skin lesions;
6. Primary involvement of the bones with secondary skin lesions;
7. Primary joint lesions;
8. Primary subcutaneous lesions.

In the past, much attention has been given to the cutaneous and subcutaneous types of the disease, due to the fact that the greater number of cases recognizable were of those kinds and hence of interest to the dermatologists. As a result, the literature comprises numerous papers on these various conditions with an intensive study of them. However, in the course of time, when other clinicians became interested because of the spread and fatality of the malady, it was noticed that pulmonary infection was very outstanding and more generalized. Ahlfeldt ('26) was able to show experimentally that both pulmonary and cutaneous infections may take place.

Numerous workers have demonstrated the entrance of the organism through an abrasion or some wound in the skin. Then, because of its frequent presence in a hot climate, such as is found in parts of California, particularly the San Joaquin Valley, the pulmonary type of infection is common, through the inhalation of the spores. It is very probable that such clinical types as mentioned previously, involving the meningeal, subcutaneous and joint lesions, in addition to the primary pulmonary and bone lesions, are primarily lung infections. This involvement may not be noticeable at first, but autopsy reports usually show positive results in these cases.

The disease is protean in its clinical manifestations, with the result that it resembles very closely various other infections, particularly tuberculosis. Its multiform clinical entities may simulate, through a metastatic action on the part of the fungus,

proliferating and suppurating processes, especially in the verrucous-like dermic lesions, as in the following: (a) The dermic lesions, which are nodular and ulcerative, in the form of painless, deep-seated, pinkish to dusky-red ulcers which become necrotic and sluggish, or may develop papillomatous growths, resembling epitheliomas, verrucas, tuberculosis in its various forms, syphilis, blastomycosis at times, and even sporotrichosis; (b) The subcutaneous coccidioidal involvement having three types of lesions —the flaccid tumor, the abscess, and the gummatous varieties may imitate cold abscesses or tumors as the names imply; (c) Pulmonary infections are usually diagnosed as pulmonary tuberculosis, but in many cases the correct diagnosis was determined post-mortem. Cases reported by Jacobson ('30), Montgomery ('00), Brown ('13), Hirsch ('23), and Taylor ('23) have given this information; (d) The osseous type of the disease has been confused with bone tuberculosis, osteomyelitis, or arthritis (Gardner, '04, Bowman, '19, Jacobson, '30). Hammack and Lacey ('24) found that twenty-one of twenty-three cases of generalized coccidioidal granuloma showed involvement of the bone. There is no roentgenological method of differentiating the disease from tuberculosis of the bone. Taylor ('23) suggested that "when bone destruction is particularly fulminating and when a proliferative process occurs along with the destruction, the diagnosis leans toward coccidioides rather than tuberculosis"; (e) Involvement of the meninges and the spinal cord usually requires a differential diagnosis from tuberculous meningitis, epidemic meningitis, and tumors of the spinal cord (Morris, '24, Rand, '30); (f) Gastro-intestinal disorders of coccidioidal granuloma require a thorough examination for the removal of the diagnosis of typhoid, as shown by Bowles ('12) and Carson and Cummins ('13). Cases reported along this line suggested very much the course usually taken by typical typhoid, and not until secondary cutaneous lesions had developed was an accurate diagnosis made; (g) Involvement of the lymph nodes usually suggests lymphatic leukemia, Hodgkin's disease, and lymphosarcoma. Ragle ('29) reported a case which early in its course resembled Hodgkin's disease and not until the cutaneous lesions appeared was the correct diagnosis given.

It would seem, therefore, that the diagnosis of coccidioidal granuloma is a difficult problem. Because of its close clinical association with tuberculosis, in order to establish the correct diagnosis it is necessary in every case to find the organism, in pus from cutaneous lesions or sinuses, in sputa, or in tissue from autopsy or biopsy material. Histopathological work does not prove anything unless the organism is seen. Frequently the lesions of coccidioidal granuloma show chronic inflammation without caseation, and some lesions may be purulent while others show the abundant necrosis typical of tuberculosis. At times, all these conditions may be present in the same section of tissue, so that it is essential that the fungus be sought. Single, negative, microscopic or cultural observations do not constitute a definite case against coccidioidal infection, for often in the presence of secondary pyogenic bacterial invaders repeated smears or cultures may be necessary before the organism can be found. Furthermore, inoculation in guinea pigs may be essential, and it is advised on all occasions.

Where the infection is of the primary visceral type with no opportunity for the study of either the tissue or the pus, the cutaneous allergic test has been applied. This consists of an intradermal injection of specific antigen obtained from a bouillon culture grown at 37° C. The filtrate of the culture, through a Berkefeld filter, contains the toxin which Jacobson ('28) claims to be an exotoxin. The principle of this reaction is that when the filtrate is injected cutaneously, a characteristic inflammatory reaction of the skin around the site of inoculation takes place in persons infected with the coccidioidal organism, whereas there is no toxic reaction in those free from the disease. This allergic cutaneous reaction may be due to an acquired cellular hypersensitiveness of the patient to the extracellular products of the organism, and the local manifestation is analogous to the tuberculin and luetin reactions. However, this method is suggested with caution and should be used only by trained investigators.

Positive tests have been reported by Davis ('24), Hirsch and Benson ('27), Jacobson ('28), and Chipman and Templeton ('30), while Cooke ('15) obtained negative results.

In addition to the types of involvement mentioned, autopsy reports reveal an enormous amount of pathological changes. These infectious conditions show the disseminating ability of the fungus. Of the great number of cases reported, the following conditions have been frequently observed:

Subcutaneous abscesses;
Lesions involving tissues of the head and neck;
Lesions involving the skin;
Meningitis and small granulomatous lesions within the brain substance;
Osteomyelitis of cranial bones with epidural or subcutaneous abscesses;
Oesophageal ulcer;
Lesions involving shoulder girdle or upper extremities;
Lesions of the thorax or its viscera;
Lesions involving the bony thorax (either ribs or sternum);
Miliary involvement of the lung;
Pneumonic consolidation simulating tuberculous pneumonia;
Fibrocaseous nodules without miliary involvement;
Caseation of hilar nodes;
Lesions involving the heart (pericarditis and endocarditis);
Lesions of the abdominal wall, spleen, liver, kidneys, pancreas, adrenals, iliac bones;
Lesions involving the whole genital apparatus, epididymus, and perirectal tissues;
Lesions of the bones of the pelvis or lower extremity;
Lesions involving the sacrum, both patellae;
Lesions in the region of the knee, and involving the ankles;
Erosion of the bodies of the vertebrae;
Involvement of the femoral, inguinal, retroperitoneal, mesenteric, lumbar, cervical, mediastinal, and peribronchial lymph nodes.

Agglutinins.—Immunological reactions have so far yielded unsatisfactory results. No agglutinins could be demonstrated by Cooke ('15), by Cummins and Sanders ('16) in experimentally infected animals, or by Davis ('24).

Precipitins.—Specific precipitins were demonstrated by Cooke ('15) in positive serum, in dilutions of 1 : 160, with an extract of

dried cultures of the organism as a precipitinogen, but negative results were obtained with the same antigen and normal serum or when specific immune serum was tested with an antigen similarly prepared from a blastomycetic organism. Positive results were obtained by other workers (Chipman and Templeton, '30), but in lower dilutions, while Cummins and Sanders ('16) report negative precipitin reactions.

Complement-Fixation.—Complement-fixation has been demonstrated with high concentrations of antigen by Davis ('24) and Chipman and Templeton ('30), whereas Cooke ('15) and Cummins and Sanders ('16) obtained negative results, although it must be pointed out that Cooke used a saline emulsion.

Specific Soluble Substance.—Hirsch and Benson ('27) and Hirsch and D'Andrea ('27a, '27b, '30) were able to demonstrate the specific soluble substance mentioned previously under the allergic reaction. Prolonged electro-dialysis of the filtrate from broth cultures causes the separation of white floccules. The dried specific substance is a white powder, not destroyed by heating to 80° C. for thirty minutes, readily soluble in water, physiologically saline, dilute alkalies (N/10 NaOH) and dilute acids (N/10 HCl), contains about 3–4 per cent nitrogen, and on hydrolysis 20–40 per cent reducing sugar measured as dextrose.

Mortality.—Coccidioidal granuloma has caused a great deal of excitement because of its high rate of mortality. Starting with as high as 100 per cent fatality, the number has gradually fallen until present reports show it to be approximately 65 per cent. As yet, this is a rather high percentage for all cases of infection, for it is probable that many cases do not reach the literature, or there may be many unrecognized mild cases, as pointed out before. Some cases may even have spontaneous recovery or become dormant and hence not noticeable. Faulty diagnosis may also be given as a reason for too few reports.

Treatment.—No wholly successful treatment of coccidioidal granuloma has been found. Recovery may be spontaneous, or death may come on slowly. Roentgen rays, surgery, iodides, and intravenous injection of crystal violet, arsphenamenes and tartar emetic have generally been unsuccessful. Antimony and potassium tartrate (Guy and Jacobs, '27) have been reported as successful by Tomlinson and Bancroft ('28) on a medical student

who had evidently contracted the disease while working on the organism. Jacobson ('27) used colloidal copper in conjunction with a special vaccine with encouraging results. Although his patients may be still alive, permanent cure is indefinite since remissions and relapses are apt to occur. In some cases, amputation of a limb has resulted in clinical cure.

Practically all races are affected, and of all the patients the greater number are males between the ages of 25 and 55. The higher percentage is in the agricultural class, the workers of the soil and its products.

Direct transmission from man to man or animal to animal has not been reported, although it is known that twenty-eight animals have had the disease. Besides, the organism has not until recently been isolated from the soil or vegetation where cases have occurred. *Coccidioides immitis* was obtained in cultures from the soil on the Delano Ranch in California where four cases had occurred among the Filipino working crew (Stewart and Meyer, '32).

Geographical Distribution.—The condition known as coccidioidal granuloma has a rather peculiar geographical distribution. Of the 286 cases reported prior to June 1, 1931, according to the bulletin issued by the California Department of Public Health ('31), 128 have been published, and a study of these cases shows that there is a decided concentration in California, in the San Joaquin Valley. Of this total number, 89.5 per cent or 254 cases originated in that state, the remaining cases having a widespread appearance as follows:[1]

South America	14
Naples, Italy	2
United States	16
Arizona	2
Colorado	3
Illinois	2
Kansas	1
Missouri	1 (total now 2)
Nebraska	2
Pennsylvania	1
South Carolina	1
Tennessee	1
Texas	1
Washington	1

[1] Coccidioidal granuloma. State of Calif. Dept. Public Health, Spec. Bull. 57: 19. June, 1931.

As a result of its frequent presence in California, the term "California disease" has become the synonym of coccidioidal granuloma. It is hard to conceive how an organism which thrives so luxuriantly in animal tissues and which apparently finds the human body an excellent host and environment for its nutrition and propagation would willingly confine its activities to such large centers as Illinois, Pennsylvania, Missouri or Texas, to one or two persons, without manifesting any further evidence of its existence for a number of years. As mentioned previously, cases are occurring with rapid recovery or incorrect diagnosis, or the benign condition of many of the cases has not aroused enough interest in the attending physician to report the case. However, the disease has been made reportable, and it is hoped that all cases will be studied for future work.

Case Summary

The case involved in this report is worthy of note, since it is the second case, at the time of publication, known to occur in Missouri. However, due to certain factors, it is probable that the primary focus was California and not the above-named state.

In 1916, during his service in the Saint Louis City Hospital, Lipsitz, in connection with Lawson and Fessenden, reported a case of coccidioidal granuloma in the 'Journal of the American Medical Association.' Tuberculous broncho-pneumonia was at first given as the clinical diagnosis, but during the course of the disease numerous abscesses developed in the muscles, thus making it of a malignant nature. Death followed seven weeks after the onset of the symptoms. This patient had never been to California. This latter fact, coupled with the malignancy, made it an outstanding case.

For the second case, a brief history of which follows, the author wishes to express his gratitude to Dr. George Ives, of the Beaumont Clinic in Saint Louis, for the material and use of the data. The patient, a Saint Louis business man of about sixty years of age, visited California in August, 1927, and spent a short time in San Francisco and Los Angeles. Two years later, July, 1929, he developed a left-sided pleurisy with effusion, for which he was treated, and his recovery seemed complete. In April, 1931,

approximately two years later, a mild arthritis of the right knee developed. During the following summer (1931), he took sun baths at Atlantic City, but to no avail.

In September, 1931, the patient consulted Dr. Klinefelter, who found the Wassermann test negative, and the Schilling and leucocyte counts to be normal. However, the joint contained a considerable amount of fluid, the removal of which gave the patient considerable relief, although temporary. There is no edema, redness of adjacent skin, or apparent increased temperature of the skin. The patient is healthy and has gained weight since diagnosis, and the evidence, except as shown above, gives no clue to a diseased person.

In contrast to the first case which was extremely malignant, this one has shown a very mild course, and it is noteworthy that these two extremes should occur in the same locality.

The joint fluid showed a light-yellow, turbid color and small masses of fibrin, with some blood and 8000 leucocytes, approximately 75 per cent of which were polymorphonuclears. Smears for bacteria were negative.

A guinea pig was inoculated with the sediment of the fluid and watched for a month, at the end of which time an indurated lesion developed at the site of inoculation and both inguinal lymph nodes became enlarged. The disease was first diagnosed as tuberculosis, but when the autopsy revealed no tubercle bacilli but did show acid-fast, imperfectly spherical bodies with granular centers the possibility of blastomycosis set in. It was from this pig that the author obtained the culture for study.

Technique

To determine the morphology and to obtain cell measurements, mycelium was mounted in hanging-drop cultures and observed. In this manner, the various steps in mycelial development were also watched.

For cellular detail, transfers were made to a solution of glycerine (Merck C. P.) and crystal violet (1 per cent aqueous). The material was cleared and stained at the same time by this method, allowing for as rapid a diagnosis as is needed where many cultures are to be examined. The time necessary for the process varies

from 20 to 40 minutes; usually 30 minutes is sufficient, although in some cases only 10 or 15 minutes are needed.

Flemming's weak-killing and fixing solution was also used, being added directly to a tube of the culture. However, since the technique involved is long and the results are not materially different, it being necessary to stain and clear the material, steps which are extensive and time-taking, the former process was used almost exclusively.

Description

The fungus known as *Coccidioides immitis* has been shown by Ophüls and Moffit in 1900 to have two life-cycles: one in the host or tissue where it appears as a double-contoured cell varying from 5 to 60 μ in diameter and showing various amounts of granulation; the other on artificial culture media where it assumes a mold-like growth, with an intertwining network of mycelium composed of variously shaped, septate hyphae.

Inasmuch as the culture used in this paper was a mycelial growth on artificial media, the author had to content himself with an examination of the slides of tissue showing the round spheres, and wait for the development of the latter in anaerobic cultures. The forms observed, however, were typical of the classical cells.

In tissue, as stated above, the fungus grows and reproduces by endosporulation, a process which has caused a great deal of trouble in the classification of the organism. Numerous workers have made a study of this particular phase of the history of *Coccidioides immitis*, and Wernicke ('92) and Rixford and Gilchrist ('96), three of the first workers, gave the earliest description of the organism in tissue, the latter making the following statement:

> "The parasite, when fully grown, is enveloped in a distinct, double-contoured capsule, and then appears as an almost perfectly spherical organism. . . . These forms vary from 15–17 microns in diameter and consist of a thick, well-developed, spherical capsule, which can be deeply stained. Between the capsule and the contents is a clear, refractive layer which usually does not stain or is stained with difficulty. This clear zone appears homogeneous and structureless; it varies in thickness from 2 to 3 microns, but is hardly discernible when the organism is undergoing sporulation. The protoplasm surrounded by the clear layer stains very readily; it is for the most part finely granular, but contains also not a few scattered, coarse granules, sometimes arranged around the periphery, at other times entering into the formation of a network. . . . The 'protozoa' present in this case are reproduced by sporulation. . . . The number of

sporozoites which are finally developed from one organism varies, but is usually very large. During the process of sporulation, the capsule can be observed to become thinner and thinner until it consists only of a faint, but well-defined membrane which finally bursts. Just before this bursting stage, the organism changes its shape and assumes an oval form. The rupture takes place at one side or at both sides of the ovoid. One photomicrograph shows a number of fine prickles extending out from the capsule, especially at the sides."

It will be noticed that Gilchrist refers to the cells as 'protozoa.' This was the opinion held by several investigators until the mycological relationship was established in 1900.

Apparently, this description has been accepted, at least for the greater part, for we find that Ahlfeldt ('29) remarks: "We have found these prickles in several sections, and they are found only in adult organisms when they are ready to liberate young forms. We are able to confirm this method of sporulation, but think that the sporulating stage assumes an elliptical rather than an oval form."

Wolbach ('04) made a careful study of the life-cycle of *Coccidioides immitis* in tissue, pus, and sputum, and found that the contents of the cells may be "finely granular, almost homogeneous, or coarsely granular, reticulated, or vacuolated." The capsule may show radial striations, although usually homogeneous, a structure similar to that observed by Gilchrist and Ahlfeldt. He found that only the homogeneous cells segmented. The process begins with a division of the protoplasm peripherally, which extends inwards, forming many segments which are separated from one another by clear spaces. This is analogous to the mode of segmentation in a fertilized frog's egg, only here the divisions are simultaneous and not arranged in a series. The hyaline membrane then develops around the future spores. By the thinning out process of the capsule, the spores are liberated and held in groups by the growth inwards of the inflammatory tissue. That is apparently why so many of these encapsulated asci may be found in masses and not spread out evenly.

Inasmuch as the spores are non-motile, it is very likely that their spread in the tissue does not take place until the process of necrosis sets in, bringing about a moist condition. In this state of the lesion, the fungus finds its way into the lymphatic or blood streams and sets up endosporulation wherever held up, an act similar to metastasis.

Since the discovery that *Coccidioides immitis* had mold-like entities, several investigators have been able to demonstrate the change from the sphere to the mycelial growth and vice-versa. When placed on artificial media, the spheres send out thin, branched, septate hyphae. This phenomenon has been observed by Wolbach ('04) and MacNeal and Taylor ('14). The number of filaments so developing is indefinite, and, if we accept Wolbach's report, come apparently from the capsule, since he states that "the protoplasm meanwhile may remain shrunken within the capsule, and without demonstrable connection with the growing filaments." This occurrence, however, is opposed to that found by the latter authors who make the following statement:

> "The capsule was penetrated at several points by blunt, protoplasmic outgrowths from the interior protoplasm. The rapidity of development of these shoots in some instances was such as to give the impression of ameboid movement at the growing tips. The shoots, at first naked cylinders of granular protoplasm, soon produced a definite, more hyaline wall about them, branched abundantly and irregularly and developed septa. After several hours, ovoid bodies of more homogeneous structure were numerous within many of the cells. After 24 hours, the circular colony had attained a diameter of one millimeter, and was made up of branched, interlacing, septate threads from 2 to 8 microns in diameter, with the old capsule of the original sphere as the center."

This latter quotation is in accord with observations made by the author on these endogenous, sporulating asci obtained in anaerobic cultures and grown on nutrient agar. The phenomenon is rather apparent, since an ascus which had fully matured and ruptured allowed the spores to spread out and develop (pl. 25, figs. 1–4). It will be seen that the spore elongates, becomes branched, with cross-walls, and the mycelial characteristics of the common molds, the varied hyphae measuring from 1 to 1½ μ in width, become abundant.

As the hyphae develop, they become wider, depending on the media on which grown, but averaging 2 to 2½ μ, being as much as 4 μ in width on some substrates. The wall becomes thicker and swellings arise on the filaments, these latter tending to form the racquet mycelium characteristic of *Coccidioides immitis* and suggestive of *Endomyces capsulatus* and the *Trichophytons* (figs. 5–12). With this increase in size the cytological detail becomes complex, and a number of deep-staining, round masses are seen which represent the nuclei and future spores. Hyphal enlargements,

measuring approximately 5 × 11 μ, become abundant as the culture gets older. These enlargements have large amounts of densely stained material representing the beginning of chlamydospore development (figs. 7–8).

With greater age there is an increased growth in width of the hyphae, the cell walls become thicker, and then there is a resorption of cytoplasm (fig. 12), representing the beginning of arthrospore formation seen in figs. 13 and 14, and the development of spores. The cell membrane becomes clear, showing a hyaline space between the inner and outer walls. The cell contents change from an irregular, granular mass to a smooth, homogeneous substance, followed by the formation of spores with a clear space around each. In the meantime, however, the structure is changing from a rather rectangular cell to a sphere. The cytoplasm, representing the connecting link between each of the arthrospores, now becoming chlamydospores and then asci, has changed from a smooth cell to a very clear membrane which either becomes absorbed by the adjacent cell wall, or completely disintegrates. From observations, it is believed that the latter of the two is the more probable. In any case the cells tend to become round (figs. 18 and 19) and may form chains or be single. On artificial media, the tendency is for the cells to remain in chains when young, and to become large and single when the culture is older.

It usually requires about 8 to 10 days for these large spheres or asci to form in a definite amount on an agar substrate, this being in accordance with the work of Ahlfeldt ('29), and several others (Ophüls, '05, Wolbach, '04, MacNeal and Taylor, '14). At the end of several weeks, the colony has become fluffy and aerial hyphae are in abundance, the asci being numerous and loose. The medium assumes a brownish color imparted to it by the mycelium which has turned to a smoky brown.

Several workers have attempted to connect both phases in the life-cycle of *Coccidioides*. Wolbach ('04) and Ophüls ('05) found similar results in that a sphere developed from a segment of the mycelium, observations compatible with those made by the author in anaerobic cultures. The work of these men consisted of injecting mycelium into animals and watching the growth. In tissue and in body fluid, within the individual, chains are very

few and the single endosporulating bodies are large. These organisms then go through the cycle described.

Cultural Descriptions

The culture furnished in this study was growing on a Sabouraud's agar slant. Colonies were many and small, spreading over the surface of the tube. Transfers were made to a series of media ranging from the more highly concentrated hydrogen ions to the less concentrated, on the pH scale roughly from 4.00 to 7.53. All cultures were grown at 25° C.

Because of its presence in a human lesion, it was thought best to use media which contained protein as a source for nitrogen. It was found, however, that the organism grew quite well on the simplest carbohydrate media as well as on agar nutrients. This is in accord with the work of Ophüls ('05) and of others, especially that of Bump ('25). In general, it was found that the organism grew quite well on a wide pH range, but the number of reproductive bodies was greatest on protein media. Inasmuch as the fungus can be identified by its microscopic morphology on various media, no particular attention was paid to its fermentative abilities at that time (Proescher, Ryan, and Krueger, '26).

Following are descriptions of colonies on several of the media on which determinations were made. These are arranged in the order of decreasing concentration of hydrogen ions.

Raulin's Solution (pH 4.15).—Colony white, filamentous, growing in large flakes partly submerged in the medium. Hyphae 1½ μ in width, long, few cross-walls, with swollen portions 2½ × 6 μ. Older hyphae show few chlamydospores and arthrospores.

Richard's Solution (pH 4.36).—Growth similar to that on Raulin's solution, mycelial growth being more abundant. Colony gray-white in color and in large filamentous flakes. Hyphae very thin, ½ to 1 μ in width, showing hyphal swellings and a few chlamydospores.

Czapek's Agar (pH 4.43).—Mycelium white, loose, cottony in growth. Hyphae 1½ to 2 μ wide, with chlamydospores and swellings suggestive of the racquet mycelium of *Trichophyton.*

Malt Extract Agar (pH 5.20).—Colony creamy-white in color, becoming brown after several weeks. Growth loose and cottony,

thick at the inoculum, forming concentric circles, and attaining a diameter of 9 cm. in 5 weeks. Hyphal swellings present, round, thick-walled chlamydospores in abundance, suggestive of the "*endoconidies*" of Vuillemin ('99), and the "*globules internes*" of Salvat and Fontoynont ('22). These measure from 4 to 7 μ in the culture.

Sabouraud's Agar (pH 5.60).—Growth rapid, cream-colored when young, becoming light brown with age. Mycelium thick, cottony, reaching a diameter of 8½ cm. in 5 weeks. Hyphae long, growing up on the side of the tube, attaining a width of 2½ μ in mature stage. Abundance of chlamydospores and arthrospores in older colonies, having various sizes and shapes. Hyphal swellings also present and numerous.

Oat-Meal Agar (pH 5.80).—Growth very loose and cottony, color white, not turning brown with age. Hyphal measurements similar to that on Sabouraud's agar.

Corn-Meal Agar (pH 6.00).—Growth loose and cottony, similar to that on oat-meal agar, reaching a diameter of 8 cm. in 5 weeks. Mycelium loose around inoculum, followed by a heavier growth. Hyphae 1½ μ in width, forming swellings 2½ to 3½ μ in width and 4½ μ in length to the normal hypha. Arthrosporous formation abundant in the older colonies.

Gelatin (pH 6.70).—Medium liquefied. Growth cone-shaped, with loose, cottony, branching, septate mycelium 2 μ in width, penetrating to a depth of 2.4 cm. in 5 weeks. Mycelium as on other media.

Beef Extract Agar (pH 6.81).—Growth loose and cottony, spread over surface of plate, reaching a diameter of 9 cm. at the end of 5 weeks. Color white, becoming brown with age. Abundance of thick-walled cells. Measurements same as on Sabouraud's agar.

Glycerine Agar (pH 7.00).—This medium consists of beef-extract agar with 6 per cent glycerine. Growth most favorable on this agar, with an abundance of spores (arthro- and chlamydo-), at first thick at inoculum with a thinner area surrounding it, that being encircled by a thick elevated mass; size of colony reaching a diameter of 3 cm. in 7 days and 8 cm. in 5 weeks. Hyphae thicker than on other media, having a width of 2½ to 3 μ, with the swollen parts attaining a width of 7 μ.

Eosine-Methylene-Blue Agar (*Product of the Digestive Ferments Co., pH 7.00*).—This medium was used merely as a part of a routine. Growth characteristic of the group, similar to that on Sabouraud's agar, with a diameter of 8 cm. in 5 weeks. Hyphae 2 μ wide, septate and branching, with the characteristic swellings and the formation of chlamydospores in the older colonies. Colony assumes a pink color which spreads over the mycelium, completely halting growth after 6 weeks.

Nutrient Agar (*Product of the Digestive Ferments Co., pH 7.27*).—Growth similar to that on beef-extract agar. Diameter of colony 9 cm. at end of 5 weeks.

Endo's Medium (*pH 7.53*).—Growth very slow, dye of medium being absorbed by inoculum, with growth stopping after 2 weeks.

Anaerobic Media.—Liborius' method of anaerobic cultivation was used.[2] Growth present, but poor, as contrasted with that in aerobic circumstances. The organism thus shows a facultative aerobic condition.

Summary of Cultural Work

The organism involved in the case mentioned previously was found to be characteristic of the fungus, *Coccidioides immitis*, based on the following properties, both culturally and morphologically, as seen in the experimental work:

1. Ability to grow on a wide variety of media as indicated.
2. Occurrence on a wide range of pH.
3. Color changes to a light brown with age.
4. Characteristic flaky growth on liquid media.
5. Condition of facultative aerobiosis.
6. Branching, septate mycelium.
7. Peculiar hyphal swellings.
8. Characteristic mycelial measurements.
9. Formation of the chlamydospores.
10. Formation of ascogenous cells.
12. Endogenous spore formation in anaerobic conditions.

[2] Method taken from Hiss-Zinsser, Textbook of Bacteriology, p. 146. New York, 1929.

Discussion

As many as are the terms applied to the disease, so varied are the names that have been used in designating the organism. If we go back to the time when the fungus was first found (Wernicke, '92), we would notice that it was called a protozoon. In fact, so great was the belief in its zoological affinity that when, some time later, two more cases were observed (Rixford and Gilchrist, '96) the medical zoologist, Dr. Stiles, was called in to render a diagnosis. He called the organism of the second case *Coccidioides immitis*, because of its resemblance to a protozoon, and that of the third case *Coccidioides pyogenes*.

Several years later, in 1900, Ophüls and Moffit, in conjunction with Ash, found that the organism was similar to a mold, and gave it the name *Oidium coccidioides*, and referred it to the class Ascomycetes. It was also termed *Oidium protozoides*.

Ricketts ('01) studied seventeen organisms and concluded that they belonged to the genus *Oidium*, distinguishing the following types as varieties: (1) Blastomycetoid or yeast-like; (2) Oidium-like; (3) Hyphomycetoid.

Verdun in 1907 prefers to call the fungus *Oidium immite*, while Brumpt ('27) insists on its classification as a hyphomycete, *Mycoderma immitis*, and to make matters more complicated, Castellani ('28) renames the genus *Blastomycoides*.

The classification of *Coccidioides immitis* has been very uncertain and the names applied to the organism very indefinite, with the result that no established taxonomic position has been assigned to it. There are those who assume that it is a hyphomycete, with definite hyphomycetous characters, but the position of these authors is very shaky as we shall see. On the other hand, many believe it to be an ascomycete, showing ascus formation and definite mycelial characteristics, and it is in this group that the classification here to be established is involved. To avoid any confusion, the California Department of Public Health has named it "fungus coccidioides," which makes an additional term to deal with.

An analysis of these terms will immediately eliminate several of them. In the first place, there is no evidence of budding in any of its forms. In the tissue, as described previously, spore forma-

tion occurs chiefly through endosporulation. In some cases, however, instances have been observed where the condition simulated budding very much, in that two spheres accidentally grew together with adjacent surfaces attached, but these cells had never become detached while young. Old cultures usually show a similar condition when two or several segments of the mycelium have never become separated by the disintegration of the cell structure between them (pl. 25, fig. 18). This phenomenon has led many to refer the organism to the genus *Oidium*, but since budding is absent from the life-cycle of *Coccidioides immitis*, it cannot be included in the group where this type of reproduction may occur.

Also, a glance at the development of mycelium and the formation of the arthrospores and then chlamydospores, producing what the author prefers to call asci, shows that they are not oidia. Thus the term blastomycete, as used in its literal sense, would be void here. Furthermore, the term *Mycoderma*, as defined by Brumpt, is equivalent to *Oidium*, and must be eliminated, since the fungus reproduces in the tissue by budding and never by endogenous spore formation. Brumpt now prefers to designate *Coccidioides immitis* as belonging to the Chytridiales of the Archimycetes. On examining the group, this view would seem a good deal more logical than the former conception, but the characteristic septate hyphae present in *Coccidioides* are lacking in the chytrids, hence that idea is amiss.

In Vuillemin's classification of the Fungi Imperfecti ('10), the groups are divided on the basis of their reproductive methods or on the kind and manner of spore formation. Thus in one of the orders, Thallosporales, the cells, thallospores, formed by the vegetative mycelium, are of a vegetative nature and not particularly suited for reproduction. Here we find accordingly two suborders: (1) the Blastosporineae which reproduce by blastospores, including the budding yeasts or yeast-like fungi, as *Monilia;* (2) the Arthrosporineae, the group reproducing by arthrospores. This latter group includes such forms as *Oidium lactis* and comprises the Actinomycetes. Two families are present: (1) the Mycodermaceae, with mycelium simulating that found in the first suborder, and; (2) the Nocardiaceae, the Actinomycetes.

Of the latter two categories mentioned above, the Mycoder-

maceae have some interest here, but, in the first place, the mycelium is monilia-like, and in the second, the arthrospores referred to in *Coccidioides* are not of that nature, *sensu stricto*, but represent an early stage in the formation of asci. Furthermore, the characteristics of *Oidium lactis* are not found in the above group. On closer study, one finds that the group classified by Vuillemin as Thallosporales has several features in common with those of the Ascomycetes, following Gaümann and Dodge ('28). As a family, however, the Mycodermaceae include too many budding forms, and that condition would eliminate the transfer of *Coccidioides* to that category.

Several writers relegate *Coccidioides* to a generic position in the Protomycetaceae (Fonseca et Arêa Leâo, '28, Basgal, '31), to which they have also transferred *Endogone*, a member of the Endogonaceae of the Zygomycetes. It must be said here, however, that these authors have dealt with the organism occurring in South America. Almeida ('28) has summarized the principle features, on a comparative basis, of the organism found in the United States and the one present in Brazil, which, if we were to accept as significant of the fungus of the latter country, should be considered as different from *Coccidioides immitis* only as a species. This Brazilian fungus is similar to that described by Posadas, and it has been named *C. brasiliensis* by Splendore in 1912, emend. F. Almeida, but the term *Posadasia esferiformis* Canton 1898 has been used to designate the fungus of that region. In view of present knowledge, however, *Posadasia* is in synonymy with *Coccidioides*, and because of priority, *esferiformis* should be used as a specific name instead of *brasiliensis*. The term *C. esferiformis* would thus constitute a species of the same genus, in the same family. In referring the genus to the Protomycetaceae, the characters of two diverse groups have been intermingled, without indicating any connecting links. Furthermore, an examination of the Protomycetaceae (Büren, '15) shows that sexuality is prominent. Although showing similarity in some degree in the mycelial characteristics, as the chlamydospores, intercalary cells and branching, phenomena which may be present in a great many other fungi, still, when we approach the essential point of differentiation, the reproductive process, the act of spore development

and dissemination pursues a different course. In the Protomycetaceae, with increasing age, the spores develop as a sheath on the inner surface of the third layer which elongates, breaks through the outer two coverings, accumulates the spores in a mass, and then shoots the aggregation into space.

Following this description of the Protomycetaceae, Mazza and Parodi ('28) have established a new genus, *Pseudococcidioides*, with properties similar to those found in *Coccidioides*. Since the growth on agar is not very well defined no exact classification can be established for this organism, but inasmuch as the whole process suggests that found in other members of the Protomycetaceae, particularly in the mode of formation of the spores and the presence of vacuoles, a tentative position as a new genus in that family may be assumed.

A reference must also be made to the genus *Rhinosporidium* which was established as a fungus by Ashworth in 1923, and which has been associated with the above genera in the family Protomycetaceae. This organism forms an ascocarp with a diameter up to 0.8 mm. Within this structure there is a great number of asci which are called pansporoblasts or morulas, which are liberated by the rupture of the ascocarp, each measuring 6 μ and containing 4 to 16 spores. An encapsulation of the organism by mononuclear leucocytes follows and then the process of growth continues. Several attempts to grow the cells on media have given no results, hence the determination as a fungus and the classification among the Phycomycetes, after Ashworth ('23), more specifically among the Olpidiaceae of the Chytridiales as Brumpt prefers it, or in the Protomycetaceae (Fonseca, '28), must of necessity rest indefinite in view of the scanty criteria present.

With this brief discussion of the conceptions of the taxonomic position of *Coccidioides*, let us turn to a consideration of the phylogenetic possibilities.

In the first place, it would seem that we are dealing with a very old organism. Here we have a fungus which has become so adapted to its parasitized host that it is able to go through a whole life cycle without a change of habitat. Of course, several steps have been eliminated in the process, but when we realize

that the end result is the same, *Coccidioides* must be considered of extreme senescence. A second proof rests on the fact that the sexual process has degenerated to the state where copulation is lost and parthenogamy prevails. A condition of this sort may be found in certain of the Hemiascomycetes where the mode of development simulates very much that of the Protomycetaceae, except that the former have copulation, either iso- or heterogamous with a definite number of spores, an advanced character, while the latter have the copulation of spores. The group constituting the former category, the Endomycetaceae, is significant in that it has been treated by many as having definite copulating forms. However, an examination of its phylogenetic relationships establishes two developmental series, that is, the isogamous, as found in *Eremascus fertilis*, and the heterogamous, as found in *Endomyces capsulatus*, or *E. Magnusii*. Both series may end in parthenogamy. This latter fact is of extreme significance here, because an association of these characters helps to establish the position of *Coccidioides*.

After due consideration of the characters presented by the members of the Hemiascomycetes and a study of the criteria involved, it appears to the author that the organism in question, namely, *Coccidioides immitis*, should be placed in the Endomycetales. Having a relationship to the Zygomycetes, on the one hand, and a semblance to the Taphrinales with the Protomycetaceae, on the other, *Coccidioides* constitutes a division comprising the affinities of both. Receiving several of its features from the Endomycetaceae and others from the Saccharomycetaceae and Protomycetaceae, makes it necessary, in view of such facts, to establish a new family, Coccidioideaceae, with *Coccidioides* as the principle genus, and to place that family in a position following the Endomycetaceae and preceding the Saccharomycetaceae. Such a division would represent the parthenogamous end of the copulation series. Although difficult to conclude definitely as to which of the two mentioned previously this fungus may belong, nevertheless, judging by the particular mode of formation of the asci, isogamy, in all probability, had prevailed.

The life cycle of *Coccidioides immitis* may be shown diagrammatically, as follows:

(a) in the tissue,

Diagram I.

(b) on artificial media,

Diagram II

In the following diagram, the position of the new family in relation to the now-existing divisions may be easily noticed:

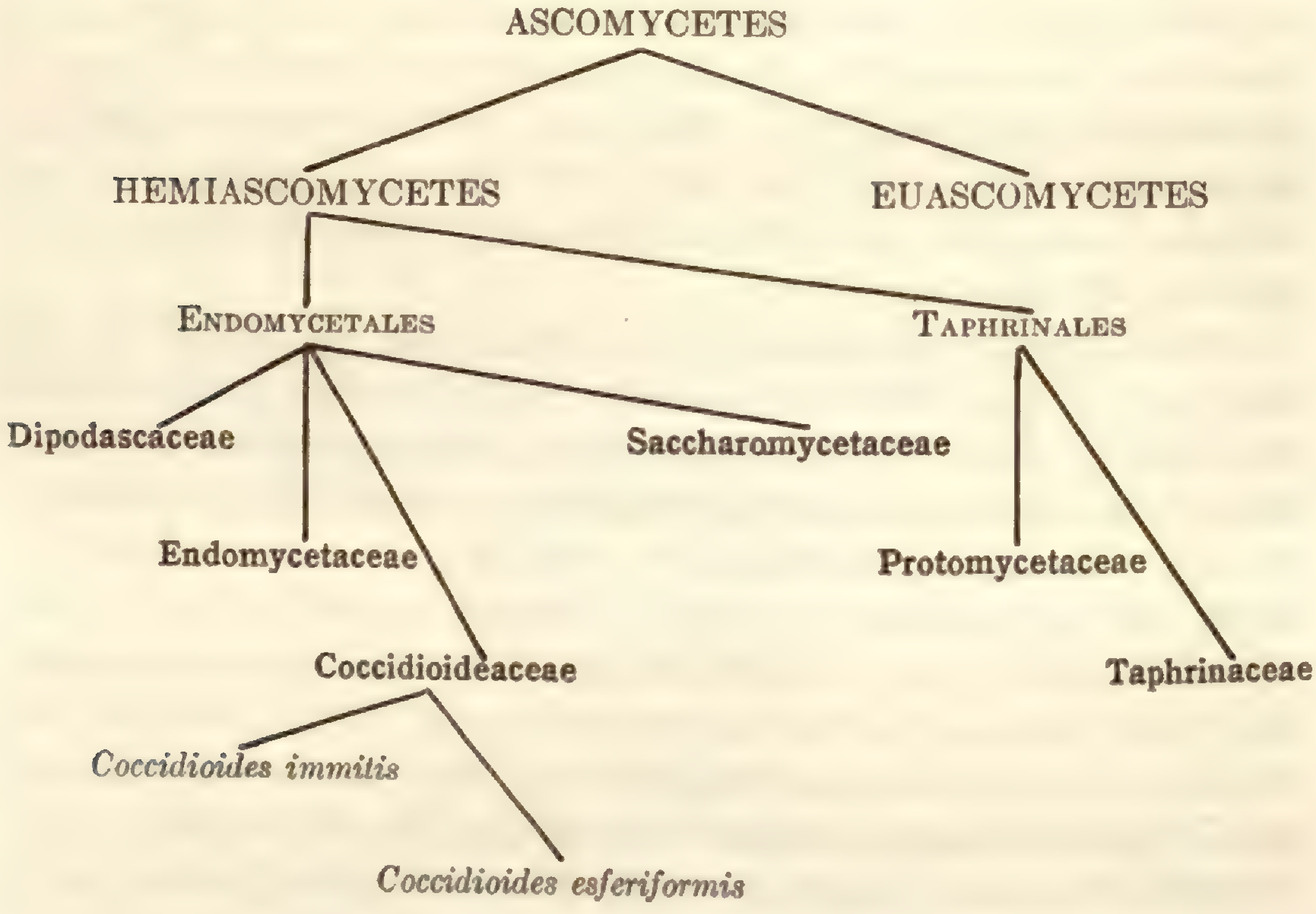

Diagram III

Coccidioideaceae Moore, new family.

This family differs from the others of the Endomycetales and Taphrinales in that the sexual development is completely lost and parthenogamy prevails; budding in any of its forms is lacking; an entire life-cycle is present in the parasitized host; endogenous,

sporulating asci arise as a result of the disintegration of the intervening cells; and finally, the number and form of development of the spores is different.

Coccidioideaceae Moore, fam. nov.

Mycelium in culturis abundans sed in hospite fere deest; asci parthenogetici singuli ex cellulis hypharum degeneratione cellularum intermediarum orti, sporae in asco multae parvae ellipsoideae, sphericaeve.

Ab Endomycetaceis sexus gemmationisque carentia, sporarum in asco multitudine, a Saccharomycetaceis mycelii abundantia differt.

Coccidioides Stiles 1896.

Growth in tissue by endogenous spore formation with many spores, round to oval; on artificial media there is an abundance of mycelium varying with the type of agar used. Hyphae septate and branching, measuring from ½ to 4 μ in diameter, characteristic hyphal swellings and formation of terminal hypnospores. Budding entirely lacking, as well as copulation. Asci form from the hyphae through the differentiation of cellular material and the distintegration of intervening cell membranes, varying from 1 to 80 μ in diameter.

Coccidioides immitis Stiles 1896.

Development by endogenous spore formation in tissue, in asci varying from 4 to 80 μ in diameter; spores numerous, round to oval. Budding and copulation lacking. On agar, colony of abundant mycelium varying from a light pink when young to a smoky-brown with age. Hyphae septate and branching, ½ to 4 μ in diameter on different media. Hyphal swellings varying from 2½ to 7 μ in width and 5 to 12 μ in length. Chlamydospores abundant, 5 to 8 μ in diameter. Terminal hypnospores several, approximately 5 × 8 μ.

Coccidioides esferiformis (Canton 1898) Moore, n. comb.

Reproduction in tissue by dehiscence of spores from the interior through the membrane, until death of cell. Asci vary from 1 to 40 μ in diameter. Growth on media difficult, optimum at pH 7.4 after 20 days. Colony white to gray. Cultural characteristics otherwise similar to the above.

With the establishment of *Coccidioides esferiformis* as a species differing from *C. immitis*, the percentage of cases occurring in California prior to June 1, 1931, plus the present case, would rise to 93 per cent. It is probable that the cases found outside of California may have had some traffic with that State as is evident from the patient here examined, and if so it shows the fungus to be endemic to the above-named region.

Summary and Conclusions

1. The history of coccidioidal granuloma is given, with a review of the early diagnosis of the organism.
2. The etiology and symptomatology show various involvements and complications and eight clinical types.
3. The immunological reactions show an incompleteness in definite beneficial results.
4. The cases show a peculiar geographical distribution, with a localization of 93 per cent of the cases due to *Coccidioides immitis* in California, and the remainder spread throughout the country and 2 cases in Italy, while many cases due to *C. esferiformis* have occurred in South America.
5. A summary of the second case known to occur in Missouri is given, showing its extremely benign course as compared with that of the first.
6. The fungus is described in detail, showing its double life-cycle: one in the tissue as a sphere, and the other on artificial media as a mold-like growth. A study of the organism reveals its relationship to the group characteristic of the Endomycetales.
7. The organism was grown on various media, showing a wide range of properties typical of *C. immitis*.
8. The phylogeny and classification of the organism is discussed, with the result that a new family, Coccidioideaceae, is established and placed in a position between the Endomycetaceae and the Saccharomycetaceae, having the affinities of both. One genus and two species are at present recognized.

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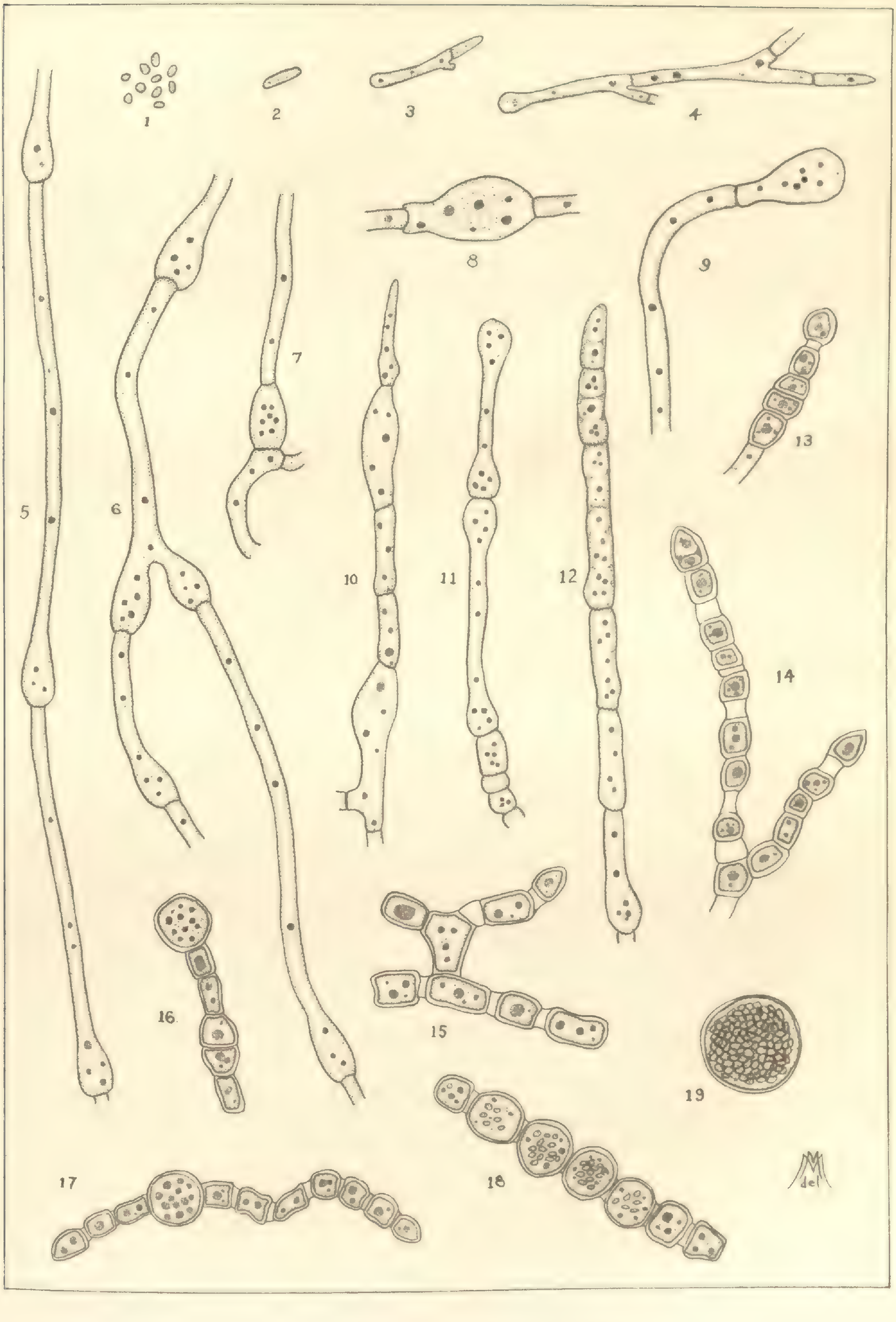
Explanation of Plate

PLATE 25

Coccidioides immitis

Fig. 1. Young spore. × 960.
Fig. 2. Developing spore. × 960.
Figs. 3, 4. Young developing mycelium. × 960.
Fig. 5. Type of mycelium on nutrient agar. × 960.
Fig. 6. Type of mycelium on Sabouraud's agar. × 960.
Fig. 7. Portion of mycelium on glycerine agar. × 960.
Fig. 8. Probably a chlamydospore on Sabouraud's medium. × 1440.
Fig. 9. Terminal hypnospore. × 1440.
Fig. 10. Young hypha on glycerine agar. × 960.
Figs. 11, 12, 13, 14. Formation of arthrospores. × 960.
Fig. 15. Branching arthrospores. × 1440.
Figs. 16, 17. Old mycelium showing chlamydospores on malt extract agar. × 960.
Fig. 18. Formation of round chlamydospores from mycelium in anaerobic culture. × 960.
Fig. 19. Large, round ascogenous cell with endogenous spores. × 960.



MOORE—COCCIDIOIDES IMMITIS

THE GENUS DALDINIA

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The separation of the genus *Daldinia* from *Hypoxylon* has been a long and gradual process, one that even to-day appears to be of doubtful value to some mycologists. It is true that some species of *Hypoxylon* show some evidence of zonation in the entostroma, and it is these species that have caused part of the difficulty in determining generic limitations, since, for the most part, no other characters than zonation of the entostroma have been found. However, the genus *Daldinia*, as understood by the writer, seems to be worthy of retention, and in fact should be retained in order to segregate a characteristic group of species from the already large and cumbersome genus *Hypoxylon.* Since many species have been described in the genus *Daldinia* which have been accepted in part only, the writer feels that a monographic study of the genus, based on the careful examination of a large number of specimens, is highly desirable.

History

The history of the genus *Daldinia* has been similar to that of most of the larger and early recognized fungi,—very varied and with many ups and downs. As originally described by Scopoli,[1] the species now known as *Daldinia concentrica*, the type of the genus, was placed in *Valsa* as *V. tubersoa.* Following this early investigator was Hudson[2] who placed the species in the genus *Lycoperdon*, using the specific name *fraxineum.* A year later, Bolton[3] applied the name of *Sphaeria concentrica.* Schaeffer,[4] in the explanation of the plate in his 'Icones,' called the species *Lycoperdon atrum*, but later in the same work[5] gave the species the name of *Sphaeria concentrica.* The classification of Bolton

[1] Scopoli, J. A. Flora Carniolica, ed. 2, 2: 399. 1722.

[2] Hudson, W. Flora Anglica 2: 641. London, 1778.

[3] Bolton, J. Hist. Fung. Halifax 3: 180. *pl. 180* of appendix. 1789.

[4] Schaeffer, J. C. Icon. Fung. Bav. et Pal. 4: 131. *pl. 329.* 1800.

[5] *Ibid.* 129. *pl. 329.* 1800.

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was accepted by Fries[6] and others, undoubtedly because there was no such confusion of nomenclature as existed in the work of Schaeffer. An examination of the synonymy of *Daldinia concentrica*, as given later in this paper, will give ample evidence of the confusion that existed in the relation to the type, which was at that time the only species of *Daldinia*, hence little more need be said about the early conception of the species.

Prior to Persoon[7] the genus *Sphaeria* was a more or less heterogeneous group of species. In 1801 he divided the genus and placed *Sphaeria concentrica* Bolt. in his new section *Periphericae* as species 11. Apparently this section was not recognized by Fries (*l.c.*), since in 1823 he placed the species in the tribe III, *Pulvinatae*, along with members of the subgenus *Hypoxylon*. At the same time he recognized two varieties of *Sphaeria* (*Hypoxylon*) *concentrica:* (b) *S. Eschscholzii* and (c) *S. obovata*. Later in 1849, Fries[8] revived Bulliard's genus *Hypoxylon* and divided that genus into three groups for which he proposed the names *Glebosae*, *Pulvinatae* and *Effusae*. *Hypoxylon concentricum* was placed in *Pulvinatae*. Meanwhile Léveillé[9] had created the tribe *Concentricae* in the genus *Sphaeria* to include, among others, his new species, *S. loculata* and *S. cingulata*, that were later assigned to *Daldinia*. In this division of *Sphaeria*, he was apparently supported by few mycologists of his time.

Daldinia, as it is understood to-day, was erected in 1863 by Cesati and DeNotaris,[10] who observed that the concentric zonation of the stroma was more pronounced in *Daldinia concentrica* than in other species of *Hypoxylon* with which the species had been formerly associated. The acceptance of the genus was not immediate, and, in fact, met with some opposition. Nitzschke,[11] in writing of *D. concentrica*, says "Die Trennung der vorliegenden und der ihr nächstverwandten, ausserdeutschen Arten von

[6] Fries, E. Systema Mycologicum 2: 331. 1823.

[7] Persoon, C. H. Snyopsis methodica fungorum 1: 8. *pl. 1, figs. 3–4.* Göttingen, 1801.

[8] Fries, E. Summa Veg. Scand., 383–384. 1849.

[9] Léveillé, J. H. Ann. Sci. Nat. Bot. III. 3: 46–47. 1845.

[10] Cesati, V. & De Notaris, E. G. Schema Classif. d. Sferiacei 4: 197–198. Gennaio, 1863.

[11] Nitzschke, T. Pyrenomycetes Germanici. 25–26. Breslau, 1867.

Hypoxylon und die Auffassung der Gruppe als besondere Gattung (*Daldinia Ces. et De Not.*), halte ich für nicht gerechtfertigt." This train of thought was also followed by Fuckel,[12] who recognized the species only as an *Hypoxylon* and admitted the existence of but one variety, namely *Hypoxylon concentricum* var. *obovatum*.

With the acceptance of *Daldinia* by Saccardo,[13] the objection to the genus appears to have lessened, although Cooke,[14] who made a study of *Xylaria* and *Hypoxylon*, wrote: "We should have preferred to have followed Nitzschke, and merged *Daldinia* (*Hypoxylon concentricum*) and *Bolinia* (*Hypoxylon tubulina*) in *Hypoxylon*. A comparison of the above characters will show that the only difference in *Daldinia* is the concentric stroma, although several of the globose *Hypoxyla* exhibit faint concentric zones when in good condition. The difference in *Bolinia* is that the perithecia are immersed, with rather long necks. These are very slight generic differences indeed as compared with some which might have been isolated, such as the very singular *Hypoxylon lycogaloides* B. & Br., and the equally strange and anomalous *H. solidum*, Schwz. If any species deserved to be raised to generic rank it was these." Saccardo's acceptance of the genus, then, marked the turning point, and from that date, separated on the conspicuously zonate character of the stroma, it has been accepted generally, even though a number of bridging species, such as *Hypoxylon Petersii*, *H. exsurgens*, *H. placentiforme*, and others, are known to exist.

Discussion of Diagnostic Characters

It has been observed by Theissen[15] that certain characters of the ascocarp vary or disappear with age, and thus alter one's conception of the species and lead to a certain amount of confusion in classification. He claims that the nature of the ostioles and the color of the ectostroma are functions of age and are not suitable for specific differentiation. This is in part true, but when such characters are correlated with others they may be very significant. Still, the changes that occur with advancing maturity

[12] Fuckel, L. Symbolae Mycologicae, Suppl. 2, p. 43. 1873.

[13] Saccardo, P. A. Sylloge Fungorum **1**: 393. 1882.

[14] Cooke, M. C. Grevillea **11**: 121–140. 1883.

[15] Theissen, F. Ann. Myc. **7**: 3–5. 1909.

or subsequent weathering must be regarded in order to make a correct determination, since some closely related species are so similar in their youth that accurate determination cannot be made unless the investigator is familiar with all members of the genus.

The nature of the ectostroma may be used to a certain extent for the rough delimitation of certain species or groups of species. Thus the degree of laccateness, as in the case of *D. vernicosa*, which is laccate and shining, is somewhat specific. This is especially true when the species are studied in the field during their prime. If they are laccate they feel smooth, slippery, and somewhat moist, especially in moist or rainy weather when a somewhat viscous liquid abundant in the stroma appears to be exuded on the surface of the fruiting body. This character, however, should be used with caution, since species that are not laccate may be shiny black or bronze-black, but they, as a rule, become dull on weathering. Laccateness may be defined as a condition of the ectostroma which, as a result of the hardening of a viscous exudation, becomes varnished, has a brilliant sheen, and therefore simulates the appearance of a wet surface. Before the ascocarps reach maturity, the laccate nature of the surface may be obscured by the presence of a brownish or grayish lavender "bloom" of conidia.

The consistency of the ectostroma, while variable and somewhat difficult to define, may be fairly constant within a species. In some species it is very thin and brittle and weathers away soon after the fruiting body has reached maturity and has discharged its ascospores (pl. 29, fig. 1a); in others it is somewhat thicker and, while more resistant to weathering, is nevertheless easily punctured by the finger-nail; and yet others have a very durable outer layer.

Wrinkling of the surface of the fruiting bodies is at best an uncertain character and of little value if considered on its own merits. This is especially true in connection with such a species as *D. vernicosa*, of which the ascocarps when mature are filled with an abundance of a viscous liquid that disappears on drying and allows the inner tissue to collapse or to become loculate, with the accompanying wrinkling of the outer surface. The pro-

portion of liquid to tissue varies not only with the age of the fruiting body but also with the weather, since during seasons of continuous rain growth is more rapid, the liquid is more abundant, and the hyphal elements appear to deliquesce more rapidly. Similarly, folding, lobing, and other gross characters appear to be influenced greatly by the nature of the substratum and by environmental conditions. Thus when growing on such porous wood as that of *Betula*, *D. concentrica* attains a larger size than it does when inhabiting a more dense substratum. As will be noted later in the discussion under *D. vernicosa*, the nature of the substratum and the environmental conditions may be an explanation of the huge fruiting bodies of the species described as *D. fissa* by Lloyd.[16] In brief, then, external characters should not be used too freely because of the pronounced effects of environmental conditions.

By means of the entostroma, the species of *Daldinia* may be divided into two easily recognized groups:—one characterized by having a dense fibrous context which is usually brown or shades of brown or brownish-gray and marked with relatively thick, darker brown, concentric zones; the other by having collapsing, white or grayish, loculate zones alternating with relatively thin darker zones. The loculate character of the stroma of the latter group appears to be the result of the loss of the abundant viscous fluid which may have been formed by the gelatinization of a portion of the hyphal elements. The darker zones, according to Miller,[17] are formed by the disintegration of perithecial initials, followed by continued growth beyond the perithecial initials to produce successive zones, the number of zones being limited by the time of formation of the perithecia. Zonation and the color and nature of the entostroma are sometimes very valuable as specific characters.

The amount of protrusion of the ostioles, while somewhat variable in some species, appears to be a valid and easily recognizable character in others. For example, *D. cuprea* and *D. clavata* are readily separated on this character alone (pl. 30, figs. 6, 7). Fortunately, there are other characters that are correlated

[16] Lloyd, G. C. Myc. Notes **7**: 1313. *pl. 306, fig. 2986.* 1929.
[17] Miller, J. H. Mycologia **20**: 328. 1928.

with this. In *D. concentrica* this character, while varying within a rather narrow range, may also be used to some extent; however, it should not be relied upon too greatly, since, when the surface is made minutely papillate by the protrusion of the ostioles, the fruiting body has a somewhat different aspect. These same words also apply to *D. Eschscholzii*, in which, as shown in pl. 29, fig. 5, the ostioles are merely punctate, whereas in other specimens (pl. 29, figs. 3, 6) they may be minutely papillate. The amount of protrusion of the ostioles, in some instances, appears to be dependent on the amount of humidity. As is shown in pl. 28, figs. 7, 8, the ostioles on the upper surface of the ascocarp are represented by papillate protrusions, while those on the lower surface of the same fruiting body, closer to the surface of the substratum, are not only papillate but *Rosellinia*-like. With such variations and exceptions in mind, the degree of prominence and the distance between the ostioles may prove a distinct aid in recognizing the species.

The size and shape of the perithecia may be somewhat variable, partly because of environmental influences, but when correlated with other characters they are sufficiently constant to be of diagnostic value (pls. 31–33). In the majority of species the perithecia are arranged in a single row around the periphery of the stroma, that is, the perithecia are monostichous; but in a few, the perithecia are polystichous and arranged either evenly or unevenly in two rows. It is possible that the polystichous arrangement may be due to the crowding of the perithecia which forced them to take positions at unequal levels; or it may be a temporary condition that has resulted from the sudden checking of growth. In any case, the polystichous arrangement often varies and may exist in one part of an ascocarp whereas in another the perithecia may be monostichous.

It is important when studying the perithecia, to cut the sections in a plane that passes longitudinally through the perithecia as close to the ostiole as possible. By this procedure errors in observing the size and shape of the perithecia will be minimized. Also, in order to determine the true nature of the ostioles, this precaution should be observed. Miller[18] makes the statement:

[18] Miller, J. H. *l. c.* 329.

"The perithecial necks do not penetrate through the ectostroma, so the ostiola are umbilicate." The writer, after a study of many sections, has come to the conclusion that all of the necks of mature perithecia do penetrate the ectostroma and at least reach the surface of the fruiting body, as is shown in pl. 31, fig. 1, pl. 32, figs. 1, 2, 4, pl. 33, figs. 1, 3, 5.

The ascospores of members of this genus are predominantly purple-black in mass, but when mounted and observed under the microscope they vary, according to the species, from amber color to brown or brownish-black. As is characteristic of most members of the Xylariaceae, the spores are provided with a longitudinal cleft through which the germ-tube subsequently grows. In certain species, such as *D. cuprea* and *D. albozonata*, the amber-colored spores have a dark brown mesospore, whereas the dark spores have an amber-colored one. The exospore is hyaline and takes the blue stain of the lactophenol-cotton-blue mounting medium. This outer layer sloughs off during the process of spore germination.

While there is no great variety of shapes among the ascospores of the different species, such differences as do exist vary but little within a single species and so may be used as taxonomic characters. Usually the spores are ellipsoid and symmetrical, but they may also be inequilaterally ellipsoid with either acutely or bluntly rounded ends (pls. 26 and 27). Again, these ends may be hyaline and refractive, but the character does not appear to be one on which too great reliance should be placed.

There is no specifically characteristic method of ascospore discharge, for in all species with which the writer is familiar in the field, the spores are ejected in long threads that soon break up. Theissen[19] has also made this observation, and Rick[20] described *D. barbata* as a new species because of the fact that the ascospores were extruded in such a manner.

[19] Theissen, F. *l. c.* 3.
[20] Rick, J. Broteria 5: 50. 1906.

Geographical Distribution

In a previous paper, the writer[21] has had occasion to remark on some of the factors that appear to be of importance in limiting the number and distribution of certain species. It is realized that by no means have all factors been considered, nor is it possible in this paper to add any further information that is based on experimental data.

Of the thirteen species recognized in this paper, but four have a relatively limited distribution, that is, they are confined to one continent or a portion thereof. Thus *Daldinia simulans*, as will be seen from an examination of the accompanying maps, is confined to the United States and is apparently not found outside of the Mississippi Valley where it has been found only in Ohio, Illinois, and Missouri. *D. clavata*, apparently a rare species, has been collected in North and South America, ranging from Mexico to Argentina. There are no doubts as to the distribution of *D. albozonata*, for this species has only been collected in Africa, being found in French Equatorial Africa (formerly Kamerun), Angola, and in Uganda. There is the possibility that the range of the species is coextensive with that of the West African rain forest. The only representative of the genus that is confined to Europe is *D. caldariorum* which is known only from the original collection that was made in a fern house in the Botanical Garden at Berlin. What significance this species might have is difficult to determine, for it cannot be said, without fear of contradiction, that the species is endemic to Europe. From the very nature of the place in which it was collected there is the possibility that the spores may have been introduced from almost any country. It has in fact been reported from Brazil.

Daldinia concentrica and *D. vernicosa* both have a very wide range of distribution, but with a few exceptions the two species appear to be confined to the regions outside of areas included between the 70° F. isotherm lines, or north of 30° north latitude. Within the boundaries of North America as thus delimited, it is obvious that the distribution has some particular climatic and humidity relation, since the species studied were collected either in river valleys or near large bodies of water, regions in which

[21] Child, M. Ann. Mo. Bot. Gard. **16**: 411–486. 1929.

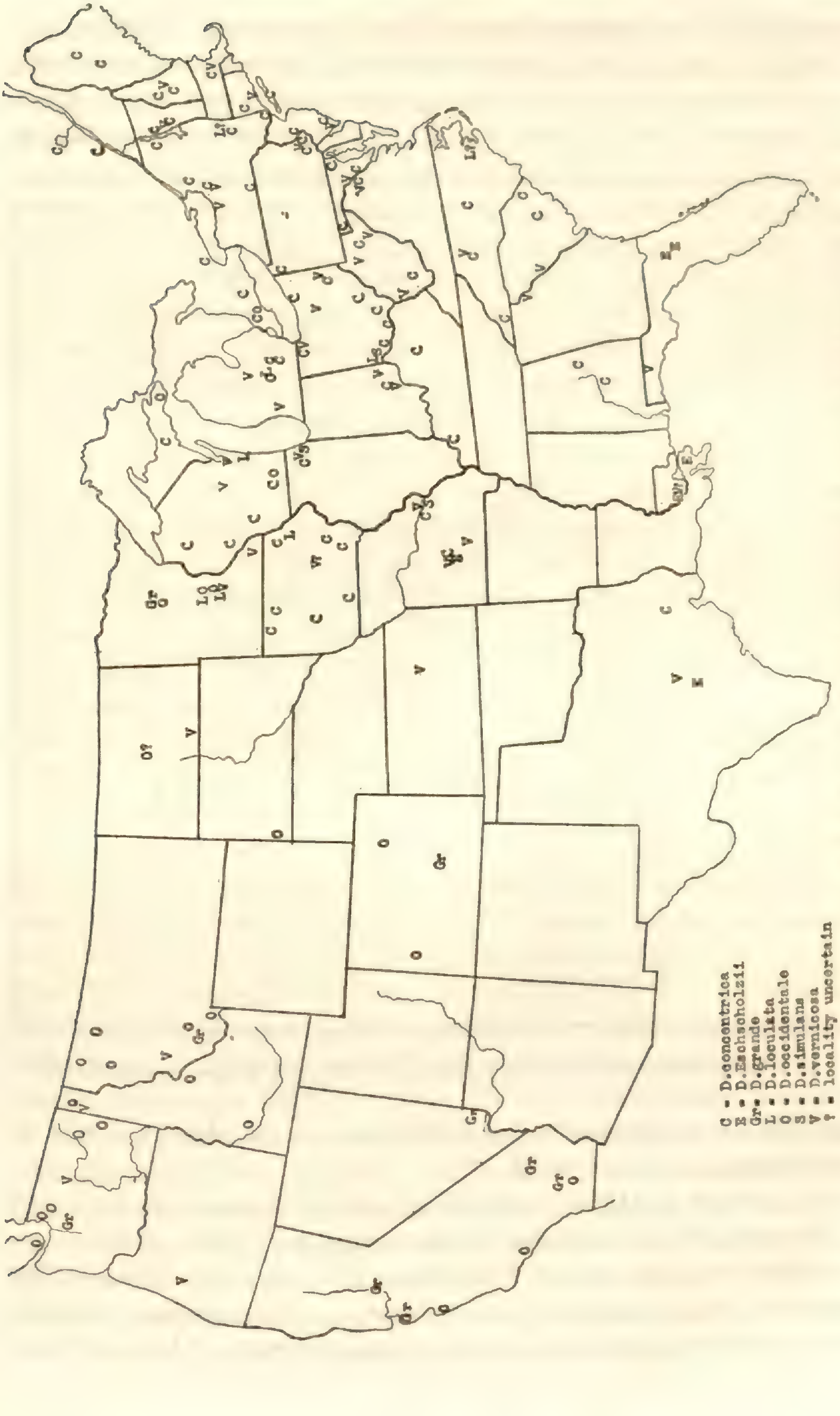

Fig. 1. Map of United States showing distribution of species of *Daldinia*.

humidity is somewhat protected by a forest cover. In Missouri, where the writer has frequently collected, these two species were almost always found along the borders of streams and in great abundance in shady damp places. It would thus appear that, in

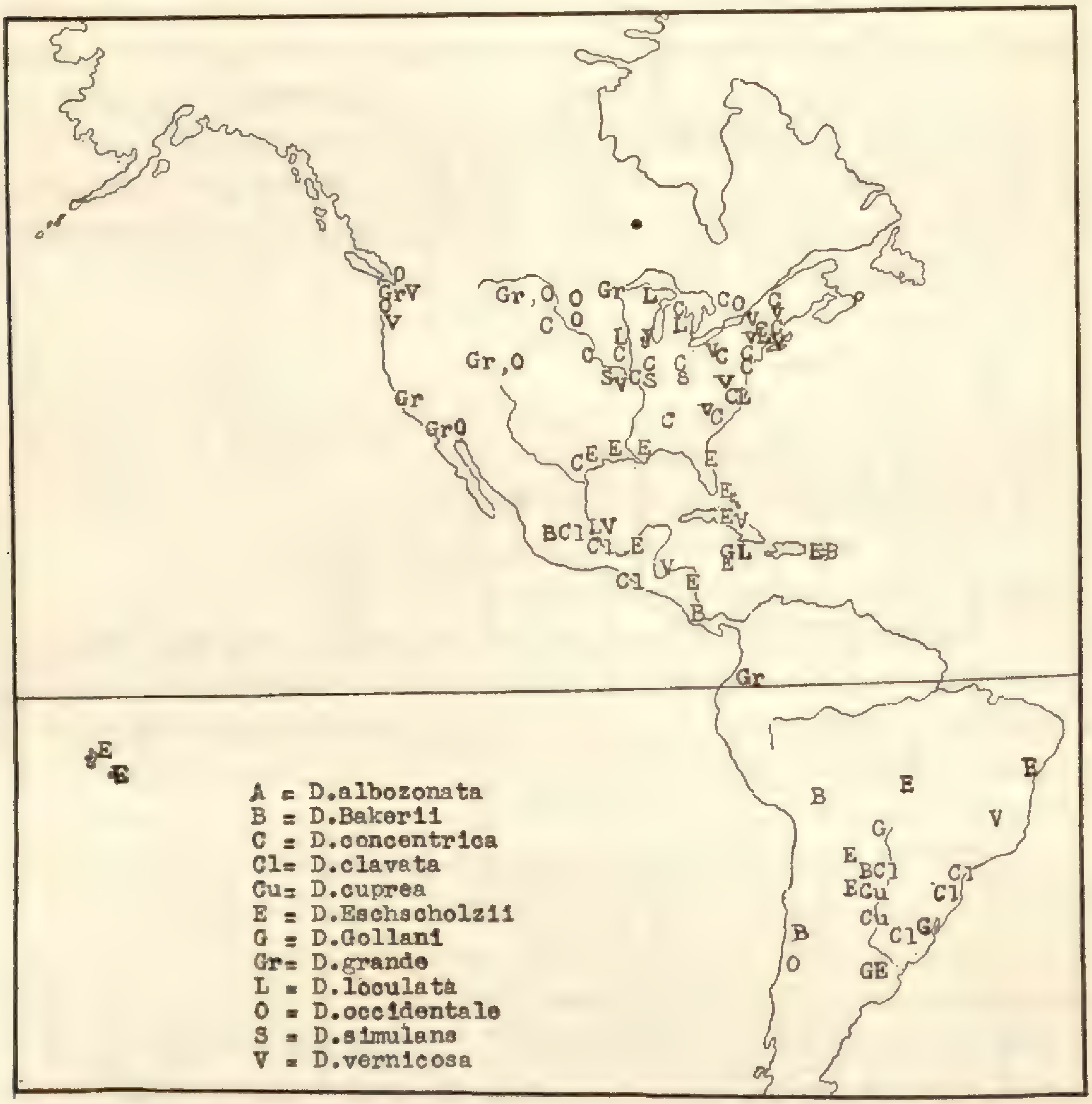

Fig. 2. Map of western hemisphere showing distribution of species of *Daldinia*.

addition to temperature, humidity plays a considerable role in the occurrence of the fungi.

In contrast to the two preceding species, *Daldinia Bakerii* and *D. Eschscholzii* are confined to the tropics and subtropics and are found only within the 70° F. isotherm lines, roughly between 30° north and south latitude, in the eastern and western hemispheres. As in the two preceding species, temperature and humidity re-

lations apparently are limiting factors in determining the occurrence of these two fungi, although a higher temperature appears to be of greater importance when the factor of humidity is favorable.

The above explanation of the distribution of the representatives of the genus would be simple were it not for the fact that the

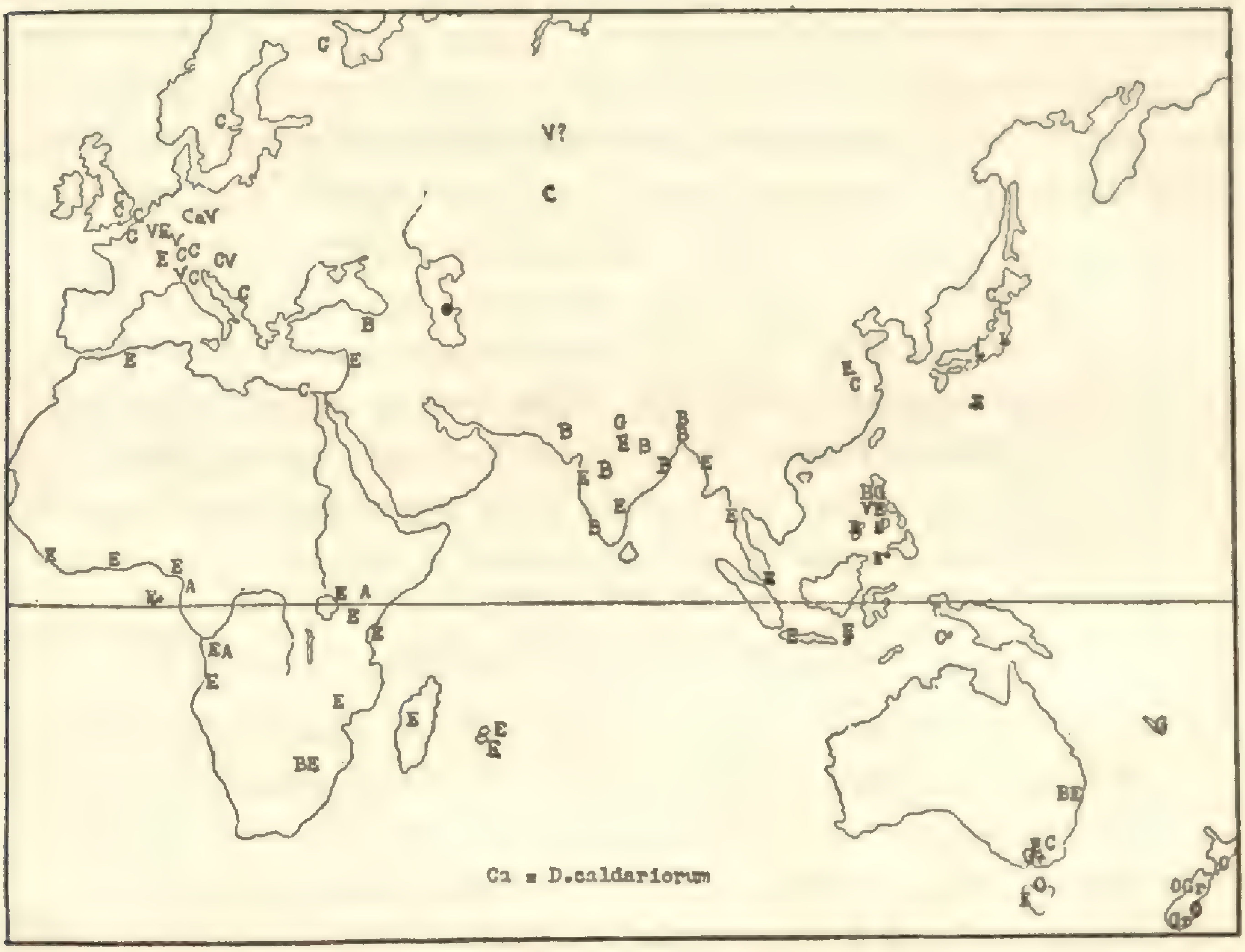

Fig. 3. Map of eastern hemisphere showing distribution of species of *Daldinia*. For explanation of symbols see figs. 1 and 2.

distribution of all species is not in agreement with such a simple explanation. *Daldinia grande,* which in North America is confined to the states west of Minnesota in the north and Colorado in the south, also occurs in Ecuador in South America, and in Australia and New Zealand. With such contrasting seasonal ranges as are represented in North America alone, it is evident that the range of the species does not coincide with any definite isothermal zone, yet if it were possible to have an intimate knowledge of the localities in which the collections were made there might possibly be some modifying circumstances that would

prove the distribution to be in general agreement with the theory suggested above.

In the present state of our knowledge, it is very difficult to find much rhyme or reason for the distribution of fungi, partially, it is true, because of the relatively few collections that have been made as compared with the number of collections of phanerogams. Furthermore, since spores may be carried over a much greater distance than the seeds of higher plants, it would seem that wide-ranging species would not be uncommon. In view of the narrow range of certain species, winds and other agencies of dispersal would appear to be of minor importance, and we would have to conclude that either the species were widespread in a former age and have become restricted by changing climatic conditions, or else that they are relatively recent and are limited by their physiological make-up. The former assumption might explain the distribution of *Daldinia grande;* the latter, that of *D. simulans.* In any case, until more data are available, discussion of the distribution must be of a speculative nature.

Materials and Methods

During the course of these investigations, free-hand sections, mounted in lactophenol-cotton blue, were employed. Because of the vast amount of material examined, this proved to be the most expeditious as well as the most satisfactory method.

Measurements of a microscopical nature were made by means of a calibrated eye-piece micrometer. It was at first thought that, in order to obtain a fair representation of the range in spore size, a large number of measurements was necessary, and accordingly one hundred spores from each ascocarp were measured. However, after comparing the count of one hundred spores with that of twenty-five, it was found that the results when plotted graphically were practically identical, and it was therefore considered unnecessary to measure more than twenty-five spores per ascocarp, especially when that number from each of several ascocarps of the same collection were measured. The results showed that there was very little variation since the spores fell within the same size-class or size-classes. Within limits, the same statement may be made in regard to the measurements of ascospores of

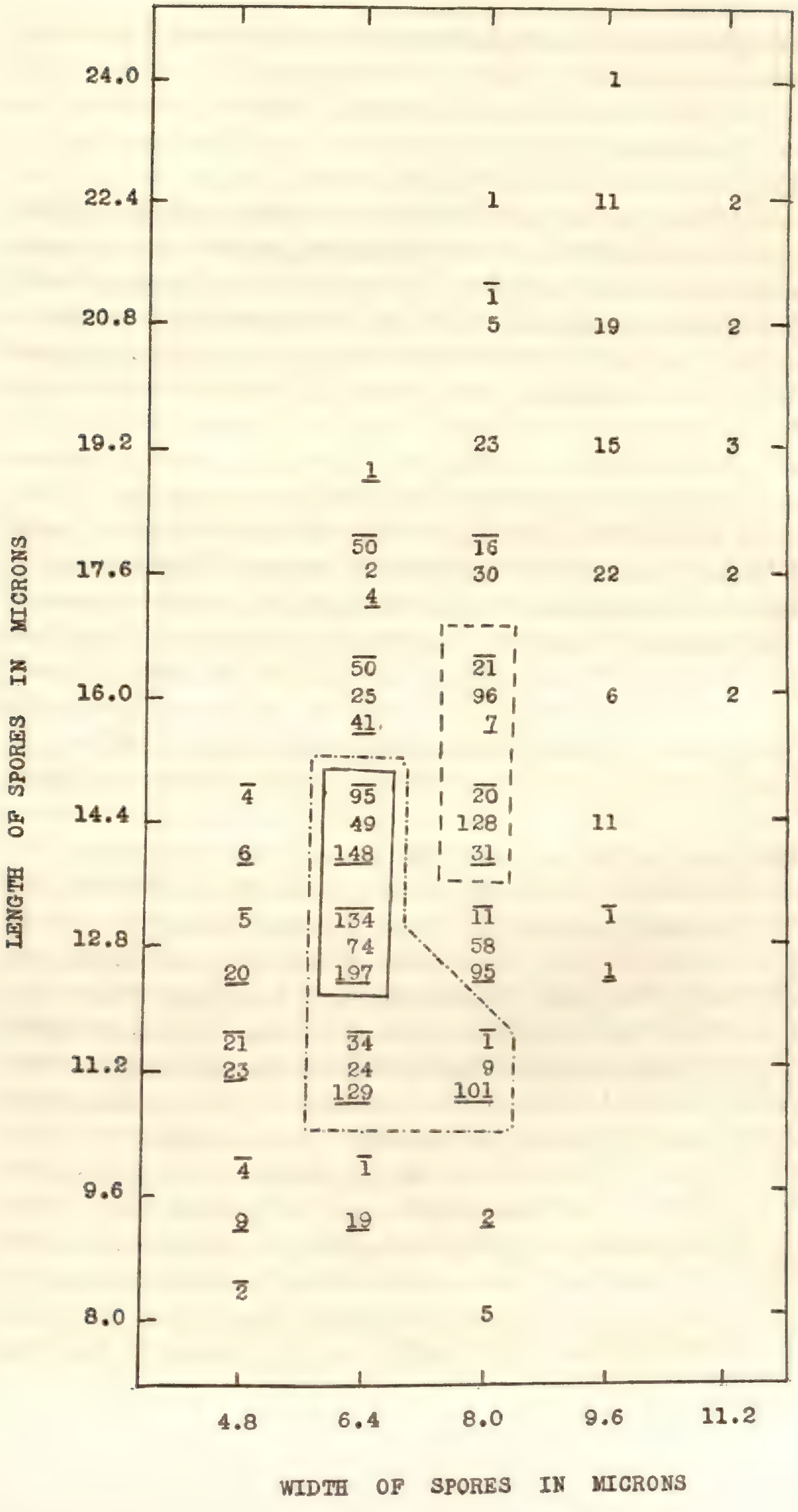

Fig. 4. Correlation table expressing application of biometrics to separation of closely related species. *D. concentrica* = $\overline{0}$ = ·–·–·; *D. grande* = 0 = – – – – – –; *D. occidentale* = $\underline{0}$ = ———.

fruiting bodies from localities that are far separated but within the same geographical region. For example, the spore size of *Daldinia concentrica* in North America is relatively constant, as is that of specimens from England, but the latter are, on the average, somewhat larger than the former.

At this point a few words should be written concerning the application of biometrics to the separation, on the basis of spore sizes, of closely related species. The results of the measurements, when expressed graphically as in the accompanying correlation table (fig. 4), in which the length of the spores is plotted against the width, show that the great majority fall within a definite range. The correlation of length to width is done individually for each spore, in order to obtain true rather than average proportions. The number of spores falling within a size-group is then expressed in numerals instead of the customary method of using a dot for each spore or unit number of spores. This method of expression, while perhaps less striking visually, has the advantage of giving the exact number of spores per size-group. Once the number of spores in the various size-groups has been plotted, it is not difficult, after a little practice, to discern where the maxima or mode for the various species fall, nor is it difficult to detect the trend of variation,—whether towards a short and broad type of spore or a long and slender type. By outlining the points of greatest frequency of spore sizes by a distinguishing line for each species studied, it is easy to detect differences between the species and thus to separate them. In separating the species, however, variations from the maxima should also be taken into consideration, since each species may show a distinctive and significant trend towards a definite size or shape. Thus the spores of *D. grande* (fig. 4) vary toward greater size and some increase in relative length; the spores of *D. occidentale* vary within a narrow range in all directions, but the shape remains fairly constant; while those of *D. concentrica* are fairly constant in width but tend to be of somewhat greater length. In this paper, then, when closely related species have been separated on spore size, not only has the mode been taken into consideration but also the trend of variation, and in the formal descriptions that follow the facts are expressed, though less exactly, in the following fashion:

"spores (8)–14.4–16–(27.2) x (6.4)–8–(11.2) μ." In this formula, the numerals within parentheses represent the extremes of spore size, and those without, the average or most frequent sizes.

Measurements of the ascocarps are given in three sets of numbers, as, for example, 2.5–3 x 2–3 x 1–2.5 cm. The first set refers to the length, the second to the width, and the third to the height of the fruiting bodies.

Colors when within quotation marks are those of Ridgway.[22]

In the citation of specimens, the following abbreviations have been employed:

A = Museo de la Plata, La Plata, Argentina.

B = Herbarium of the Botanical Museum, Berlin-Dahlem, Germany.

F = Farlow Herbarium, Harvard University, Cambridge, Mass.

Ia = Herbarium of the University of Iowa, Iowa City, Ia.

L = Herbarium of the late C. G. Lloyd, Smithsonian Institution, Washington, D. C. The numbers cited in this paper are those given by the U. S. Department of Agriculture to replace those of Lloyd.

Li = Herbarium of David H. Linder, Harvard University.

MBG = Herbarium of the Missouri Botanical Garden, St. Louis, Mo.

NC = Herbarium of University of North Carolina, Chapel Hill, N. C.

NY = Herbarium of the New York Botanical Garden, Bronx Park, New York City.

P = Herbarium of the Museum of Natural History, Paris, France.

Pa = Herbarium of the Academy of Natural Sciences, Philadelphia, Pa.

PDS = Herbarium of Plant Disease Survey, U. S. Department of Agriculture, Washington, D. C.

Po = Herbarium of Alfred H. W. Povah.

S = Herbarium of C. L. Shear, U. S. Department of Agriculture.

[22] Ridgway, R. Color standards and color nomenclature. Washington, D. C., 1912.

Sh = Herbarium of Paul Shope, Boulder, Colorado.
St = Herbarium of the State Museum, Stockholm, Sweden.
T = Herbarium of the University of Texas.
W = Herbarium of Leva B. Walker, Lincoln, Nebraska.

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Taxonomy

DALDINIA

Stromata superficial, hemispherical, subglobose, globose, turbinate, or clavate, sessile, substipitate or stipitate. Ectostroma carbonaceous, at first pruinose, later dull black, shining, or laccate. Entostroma dense or lacunate, white, gray, or brown, *conspicuously concentrically zonate.* Perithecia claviform to subglobose, immersed in the stroma, not umbilicate with obsolete to protruding or papillate ostioles. Asci cylindrical, soon disappearing, 8-spored, the spores obliquely uniseriate. Ascospores simple, ellipsoid to navicular, light to dark brown, translucent or opaque.

The genus as here understood is separated from *Hypoxylon* by its conspicuously zonate stroma. In some species of *Hypoxylon,* however, there may be slight indications of zonation, but these have been excluded from the genus. Usually the ascocarp of *Hypoxylon* varies from resupinate to sessile; rarely are they substipitate, and never stipitate. Also, while tropical forms of *Hypoxylon* may attain enormous sizes and simulate *Daldinia* externally, the ectostroma is usually very much roughened, very thick, and the entostroma very dense and homogeneous or woody.

KEY TO THE SPECIES OF DALDINIA

1. Inner context dark brown or brownish, persistent, dense. (See also *D. Bakerii*) 2
1. Inner context light, lighter zones white or some shade of gray, dense or collapsing, with persistent dark zonal lines 6

2. Ascocarp sessile or substipitate, stipe when present broad, exceeding 5 mm. in thickness and not cylindrical....................................3
2. Ascocarp definitely stipitate, the stipe cylindrical, less than 5 mm. thick and supporting a globose to subglobose fertile head..........*8. D. loculata*
3. Ostioles obsolete to punctiform; ascocarp smooth or very slightly papillate; spores (8)–11.2–(14.4) x 4.8–(6.4) μ....................*4. D. Eschscholzii*
3. Ostioles prominent, papillate to mammiform; ascocarp somewhat rough to rough..4
4. Ascospores (8)–14.4–16–(27.2) x 6.4–8.–(11.2) μ; ascocarps usually large, irregular, always sessile; perithecia mostly polystichous........*3. D. grande*
4. Ascospores smaller; ascocarps not as above..............................5
5. Mature ascocarps bronze-black; spores bluntly rounded, (9.6)–12.8–(19.2) x (4.8)–6.4–8–(9.6) μ.................................*2. D. occidentale*
5. Mature ascocarps vinaceous-black to dull black; spores rounded, tapering at either end, (8)–12.8–14.4–(20.8) x (4.8)–6.4–(8) μ......*1. D. concentrica*
6. Inner context dense, not collapsing.....................................7
6. Inner context loose, collapsing...9
7. Ostioles prominent; ascospores (9.6)–14.4–(24) x (4.8)–6.4–(11.2) μ. .*5. D. Bakerii*
7. Ostioles obsolete to punctiform...8
8. Perithecia subspherical; ascospores (6.4)–9.6–(12.8) x (3.2)–4.8–(6.4) μ. ....*6. D. Gollani*
8. Perithecia elongate-ovoid; ascospores (9.6)–11.2–(14.4) x 4.8–(6.4) μ....... ....*7. D. caldariorum*
9. Ascocarps turbinate or irregularly turbinate..........................10
9. Ascocarps clavate...12
10. Spores small, (6.4)–8–(9.6) x (2.4)–3.2–(4.8) μ...............*11. D. albozonata*
10. Spores larger...11
11. Ascocarp vinaceous, laccate at maturity; stipe inconspicuously zonate; spores (8)–11.2–12.8–(17.4) x (4.8)–6.4–(8) μ...............*9. D. vernicosa*
11. Ascocarp drab or drab-brown; stipe zonate; spores (9.6)–11.2–(14.4) x (4.8)–6.4–(8) μ.......................................*10. D. simulans*
12. Perithecia confined to the upper part of the stipe-like stroma, with conspicuous ostioles; stipe externally zonate with annulate thickening...*12. D. cuprea*
12. Perithecia over entire stroma, not confined to upper half; ostioles obsolete to punctiform...*13. D. clavata*

1. **Daldinia concentrica** (Bolt.) Cesati & DeNotaris, Schema Classif. d. Sferiacei 4: 197. 1863.

Fungus fraxineum etc. Raius, Hist. Pl. 1: 109. 1686; Syn. Stirp. Brit. ed. 3. 16. No. 20. 1724.

Valsa tuberosa Scopoli, Fl. Carniolica, ed. 2. 2: 399. 1722.

Lycoperdon fraxineum Hudson, Fl. Angl. 2: 641. 1778.

Sphaeria concentrica Bolton, Hist. Fung. Halifax 3: 180. *pl. 180* of appendix. 1789.

Sphaeria tunicata Tode, Fung. Meckl. Sel. **2**: 59. *pl. 17, fig. 130 a–g.* 1791.

Lycoperdon atrum Schaeffer, Icon. Fung. Bav. et Pal. **4**: 131. *pl. 329.* 1800 (as *Sphaeria concentrica* p. 129).

Sphaeria fraxinea Withering, Arrang. Brit. Pl. ed. 5. **4**: 429. 1812.

Sphaeria hemisphaericae Nees, Syst. d. Pilze **1**: 291. 1817.

Sphaeria concentrica Bolton ex Fries, Syst. Myc. **2**: 331. 1823.

Stromatosphaeria concentrica Greville, Fl. Edinensis, 355. 1824.

Sphaeria (*Pulvinata*) *placenta* Link, Linnaea **5**: 539–540. 1830.

Hemisphaeria concentrica Klotzsch, Acad. Caes. Leop. Nova Acta **19**: 241. 1843.

Pl. 27, fig. 4; pl. 28, fig. 4; pl. 29, figs. 1–2, 4, 7, 9; pl. 30, fig. 1; pl. 33, fig. 1.

Stromata hemispherical to globose, sessile to stipitate, single or coalescing, 1.1–10 x 1–7 x 1–7 cm., rubiginous when young, erumpent from the bark or superficial on decorticated wood. Ectostroma moderately thin, "Dark Vinaceous Brown," "Sorghum Brown," "Hay's Brown," "Drab," "Army Brown," or more frequently "Vinaceous Brown," later becoming black and either dull or shiny. Entostroma densely fibrous, persistent, conspicuously concentrically zoned, the lighter "Dilute Snuff Brown," "Fuscous," "Hair Brown," "Benzo Brown," or "Deep Mouse Gray" zones up to three times wider than the darker "Bone Brown" zones. Perithecia usually monostichous, rarely polystichous, claviform to subclaviform, 518–1776 x 185–592 μ, the walls 14.8–37 μ thick. Ostioles punctiform to somewhat prominent. Ascospores inequilaterally ellipsoid, brown, the ends sometimes of a lighter color and more refractive, (8)–12.8–14.4–(20.8) x (4.8)–6.4–(8) μ. Conidia ellipsoid, hyaline, 2.4–3.2 x 4.8–6.4 μ.

On wood of a wide variety of deciduous trees. Cosmopolitan. Bolton described this species in 1789, and since that time it has

been glorified and belittled by various descriptions and synonyms. Persoon[23] described the variety *pedicellata* of *Sphaeria concentrica,* but in his figure 4 the longitudinal section of the fruiting body clearly shows the entostroma to be white, and, together with the characters of the fruiting body as a whole, shows that the variety should be considered as synonymous with *D. vernicosa.* In referring to the figures in the text (p. 8, β), Persoon refers to the variety *pedicellata* of the plate as variety *stipitata.* Variety *obovata* is also ascribed to this writer by Fries,[24] but this is an obvious misunderstanding which apparently resulted from the fact that the first word of an indented line was "obovata." Fries also linked Nees with this error, and in 1882 Saccardo[25] also ascribed the variety to Nees and mentions that it is close to *D. vernicosa.*

Fries[26] makes *Hypoxylon durissimum* (Schw.) Berk. a synonym of *Sphaeria concentrica,* but Cooke[27] says that the species should be considered synonymous with *Hypoxylon marginatum.* A photograph of the exterior and a preparation of ascospores from the type have been studied by the writer who is inclined to follow Cooke's belief, at least as far as the generic status is concerned.

The fruiting bodies of this species are fairly constant in their macroscopical appearance, but exceptionally, when the species grows on soft porous wood such as birch, they attain a greater size. The ascospores of these large forms, however, are in agreement with those of the typical material. As has been previously noted (p. 442) the spores from European material tend to be somewhat larger than those of typical American material, although they are in general agreement, and hence it seems to the writer that the creation of a variety is scarcely warranted.

Specimens examined:

Exsiccati: Allescher & Schnabel, Fungi Bavarici, 76; Bartholomew, Fungi Columb., 2013; Cooke, Fungi Brit. Exsicc. I, 669; Cooke, Fungi Brit. Exsicc. II, 216; de Thümen, Myc. Univ., 10883; Fries, Scleromyceti Sueciae, 141; Karsten, Fungi Fennici, 265; Linhart, Fungi Hungarici, 261; Plowright, Sphaer.

[23] Persoon, C. H. Syn. Meth. Fung. **1**: 8. *pl. 1, figs. 3–4.* 1801.

[24] Fries, E. *l. c.* 1823.

[25] Saccardo, P. A. Syll. Fung. **1**: 393. 1882.

[26] Fries, E. Nov. Symb. Myc. 114. 1851.

[27] Cooke, M. C. Grevillea **11**: 131. 1883.

Brit., 17; Ravenel, Fungi Caroliniani, Fasc. III, 49; Roumeguére, Fungi Gall. Exsicc., 3946; Torrend, Fungi Sel. Exsicc., 142.

CANADA: Quebec, Lake St. John, Aug. 1910, *Isabel M. Walker* (L 10908); *G. Ducharne* (L 12300); Ontario, *Isabel M. Walker* (L 10915); London, on decaying wood, July 1904, *John Dearness, 2013* (F); Toronto, July 1908, *Thos. Langton* (L 10926).

UNITED STATES:

Maine: Milo, on alder, Aug. 18, 1920, *C. L. Shear* (S 5582); Mt. Katahdin Trail, on *Fagus* log, Aug. 21, 1920 (S); *C. C. Hanmer* (L 11055).

New Hampshire: Hanover, on *Alnus*, Sept. 30, 1902, *A. H. Chivers* (F); Grantham, *Kate Jones* (L 10886, 12301); Hebron, on *Ulmus* post, *Mrs. R. D. Randlett* (L 10660).

Vermont: Middlebury, Oct. 1910, *C. G. Lloyd* (L 10918); Pawlett, on *Betula papyrifera*, April 17, 1925, *D. H. Linder, 598* (Li); Winooski, *D. B. Griffin* (L 10939).

Massachusetts: Waltham, Sept. 7, 1913, *G. E. Morris* (L 10916).

Connecticut: Morris, Aug. 1915, *B. O. Dodge* (PDS); without locality, *T. H. MacBride* (Ia 1345).

New York: Adirondacks, *F. H. Ames* (L 10874), *E. Knäbel* (L 10818, 10903); Berne, on maple, Aug. 31, 1925, *C. L. Shear* (S); Brooklyn, Oct. 24, 1914, *F. H. Ames* (L 10873, 10906); Buffalo, *G. W. Clinton* (F, PDS); Long Island, *G. C. Fisher* (L 10921); Orient, on *Quercus*, Aug. 19, 1921, *Roy Latham* (L 12177); Ithaca, on *Hamamelis virginiana*, April 30, 1893, *Atkinson* (MBG 15977), Oct. 2, 1910, *F. A. Wolf, 60* (PDS); July 10, 1901, *C. O. Smith* (PDS); Syracuse, *L. H. Pennington* (L 10819); Watkins, on *Ulmus* stumps, July 2, 1892, *D. G. Fairchild* (PDS).

New Jersey: Newfield, *J. B. Ellis* (PDS); Trenton, *E. B. Sterling* (L 10922).

Pennsylvania: Philadelphia, *Mrs. Hannah Streeter* (L 10917, 10933); Mauch Chunk, Sept. 13, 1914, *C. J. Humphrey* (L 10808); without locality, *Eliz. C. Cox* (L 10825).

Maryland: Analostan Island, on rotten *Celtis*, Sept. 14, 1919, *C. L. Shear* (S); Baltimore, *Chas. C. Plett* (L 10931); Grand Falls, April 19, 1925, *F. T. Eagan* (PDS); High Island, on

Betula nigra, July 29, 1922, *A. E. Jenkins* (PDS); Island Park, Sept. 16, 1918, *C. L. Shear* (S), on wild *Vitis*, Sept. 16, 1918, *C. L. Shear* (S); Leitersburg, *W. T. Lakin* (L 10884); Mid River Island, on bark, July 4, 1924, *F. T. Eagan* (PDS 66346); North Beach, June 11, 1922, *E. K. Cash* (PDS); Oakland, Sept. 17, 1917, *C. L. Shear* (S), on *Crataegus*, Sept. 17, 1917, *C. L. Shear* (S 5583), on young and old maple logs, Sept. 17, 1917, *C. L. Shear* (S); Oxen Run, on *Carpinus*, Oct. 21, 1921, *J. R. Weir* (PDS); Plummers Island, on *Acer*, Sept. 28, 1919, *C. L. Shear* (S); Sycamore Island, on *Rhus*, May 15, 1927, *A. E. Jenkins* (PDS).

District of Columbia: Rock Creek Park, on *Platanus occidentalis*, Sept. 24, 1916, *H. R. Rosen & E. H. Siegler* (PDS), *E. Knäbel* (L 10935), on *Quercus alba*, June, 1912, *J. R. Weir, 7462* (PDS).

Virginia: Arlington Farm, Dec. 1916, *C. L. Shear* (S); Black Pond, Aug. 13, 1922, *E. K. Cash* (PDS); Clarendon, on *Acer rubrum*, April 6, 1923, *W. W. Diehl & J. R. Weir* (PDS), on *Acer* ?, March 11, 1923, *J. R. Weir* (PDS), on *Acer rubrum*, Jan. 3, 1926, *J. R. Weir* (PDS), on *Diospyros virginiana*, Oct. 10, 1926, *J. R. Weir* (PDS 66660); Dead Run, Fairfax Co., Sept. 30, 1923, *E. K. Cash* (PDS); Great Falls, on *Acer saccharinum*, Aug. 12, 1926, *J. R. Weir* (S), on *Acer Negundo*, Oct. 30, 1925, *F. T. Eagan, 441* (PDS); without locality, apple orchard, *A. M. Beckwith* (PDS).

North Carolina: Canton, *William Holden* (L 10909); Chapel Hill, on dead birch, fall of 1928, *Andrews* (NC 8259), on bark of deciduous trees, Sept. 1922, *W. C. Coker* (NC 5399); Winston Salem, on decaying stump, Aug. 1922, *Dr. Shallert* (NC 8555); Waynesville, on osage orange, *Mary Fitzgerald* (L 10940, 10943).

South Carolina: Pisgah, on *Betula lutea*, July 16, 1910, *A. H. Graves* (L 11877); Pee Dee River, Nov. 7, 1920, *C. L. Shear* (S).

Alabama: Auburn, on willow, Nov. 25, 1897, *F. S. Earle* (MBG 16365), 1896, *Underwood* (Ia); Montgomery, *R. P. Burke* (L 10907).

Ohio: Adams County, May 4, 1930, *A. H. W. Povah* (Po);

Barnesville, *Emma E. Laughlin* (L 10885); Cincinnati, July 1884, *Dr. Byrones* (PDS), Oct. 2, 1919, *H. Cugner* (PDS 6581), Sept. 8, 1920, *C. G. Lloyd* (L 11765); Linwood, Aug. 26, 1920, *C. G. Lloyd* (L 10820); Mineral Springs, May 4, 1930, *A. H. W. Povah* (Po 3); Norwood, July 1897, *C. G. Lloyd* (L 10945); Oberlin, *Emma J. Carl* (L 10924); Oxford, small logs, Oct. 12, 1920, *B. Fink, 1048* (PDS, F); Salem, *B. Leeper* (L 10864); Toledo, *W. R. Lowater* (L 11794), *Mrs. Albert J. Wolfert* (L 10888).

West Virginia: Cooper's Rock, on *Betula lenta* (?), July 28, 1907, *C. L. Shear, 3048* (PDS); Eglon, Sept. 5–10, 1915, *C. G. Lloyd* (L 10914); Fairmont, *Rev. A. Boutlou* (L 10811, 10812, 10835, 10853, 10887); Fayette Co., April 15, 1893, *L. W. Nuttall, 905* (PDS).

Michigan: Ann Arbor, on *Acer rubrum*, Sept. 10, 1894, *L. N. Johnson* (Po 229a), on *Betula* logs, July 1914, *E. B. Mains* (PDS 12388); East Lansing, *E. A. Bessey* (L 10822); Rock River, on *Alnus*, Aug. 24, 1927, *A. H. W. Povah* (Po 229d).

Indiana: Scottsburg, 1907, *J. R. Weir, 8964* (PDS), on *Hicoria ovata*, May 1901, and June 1912, *J. R. Weir, 2751, 7433* (PDS).

Kentucky: Crittenden, Oct. 5, 1914, *C. G. Lloyd* (L 10937); Lexington, *H. Garman* (L 10905).

Wisconsin: Dells, June 1927, *A. H. W. Povah* (Po 1); Hayward, Sept. 30, 1919, *C. J. Humphrey* (L 10810); Madison, on *Acer*, Aug. 9, 1920, *E. E. Hubert* (L 10807); River Falls, Oct. 1887, *F. H. King* (MBG), Oct. 1887, *Wm. Trelease, 2* (MBG).

Illinois: Evanston, Sept. 29, 1928, *H. Fox* (Po 229); without locality, *MacDougal* (L 10852).

Iowa: Decorah, on logs, Sept. 5, 1885, *E. W. D. Holway* (PDS); Decatur Co., Nov. 6, 1900, *R. L. Smith* (Ia 1350); Fairfield, *J. F. Clarke* (L 10934); Fort Dodge, *O. M. Oleson* (L 10850); Iowa City, *J. A. Perish* (Ia), July 29, 1923, *G. W. Martin* (Ia 1174); Spirit Lake, July 16, 1926, *G. W. Martin* (Ia 1077); Turkey Creek, Johnson Co., July 12, 1902, *B. Shimek* (Ia 1349).

Missouri: Creve Coeur, St. Louis Co., on wood, Aug. 7, 1891, *Dr. Lind* (?) (MBG 16363); Dixon, on *Betula*, Aug. 1930,

Marion Child (MBG), on *Platanus*, Aug. 1928, *Marion Child* (MBG); Meramec, on old wood, Nov. 1905, *P. Spaulding* (MBG); Pleasant Valley, St. Louis Co., on *Betula*, Sept. 1928, *Marion Child* (MBG); St. Louis, Forest Park, on *Ulmus*, Oct. 17, 1896, *H. von Schrenk* (MBG 43049), on dead trunks, July 4, 1898, July 19, 1902, *H. M. Glatfelter, 50* (MBG).

Nebraska: Weeping Water, April 19, 1924, *L. V. Walker* (W).

Texas: Houston, on fallen limbs, 1869, *H. W. Ravenel* (PDS).

Europe:

England: Kings Lynn, Norfolk, on decayed *Fraxinus excelsior*, 1874, *C. B. Plowright, 69* (F, PDS, Ia, St, L 10883), *C. B. Plowright, 216* (F); Crediton, on felled trees, Nov. 21, 1904, *Mrs. A. Montague* (L 10893); Dewesbury, on *Fraxinus*, *E. M. Wakefield* (PDS); Lancashire, Oct. 8, 1910, *H. J. Wheldon* (L 10872); London, *E. M. Holmes* (L 10828, 10895); *M. C. Cooke, 669* (F); Somerset, on dead trunks, June 1875, *Mac Owan & Tuck* (St 17); Southhampton, *M. C. Potter* (L 10894).

France: Pas-de-Calais, *C. Cepede* (L 10871, 10877); Seine-et-Oise, March–Aug. 1886, *F. Sarrazin* (MBG 16366).

Germany: Munich, on *Alnus glutinosa*, May 1910, *J. R. Weir, 2750* (PDS), on *Fagus*, 1910, *J. R. Weir, 2756* (PDS); Oberammergau, Aug. 1889, in Fungi Bavarici, *Schnabel, 76* (F, St 32); Reigenwalsermunde, on *Alnus incana*, 1892, *P. Sydow* (St 8); without locality (St 21).

Austria: Vorarlberg, on beech, winter, 1898, *J. Rick, 1228* (F, St); Wiener Wald, Nov. 3, 1890, *von Höhnel, 4350* (F).

Sweden: Bygget, *C. G. Lloyd* (L 10898); Upsala, 1909, *C. G. Lloyd* (L 10879).

Finland: Kuusamo, *Karsten, 265*, in Fungi Fennici (F).

Switzerland: 1821, *Fries, 141*, TYPE collection (F).

Italy: on *Alnus glutinosa*, 1923, *Bresadola* (PDS); Lombardy, 1889 (PDS); Trieste, on trunks of various dead trees, Sept. 1874, *Saccardo, 697* (PDS); without locality, *Cesati, 600* (F).

Rumania: Siebenbürgen, on *Betula alba*, Aug. 1883, *Linhart, 216*, in Fungi Hungarici (PDS, F).

Jugo-Slavia (Serbia): immature specimen (St).

Russia: Novogorad, Prov. of Bologoi, on *Acer platanoides*, July 6, 1918, Aug. 30, 1918, *W. Tranfeschel* (St 35, 129).

AFRICA:

Egypt, on *Betula alba*, Aug. 1883, *Römer, 261* (F).

ASIA:

Siberia: Prov. of Omsk, Tara Distr., on limbs of *Betula verrucosa*, Sept. 7, 1921, *Murashinsky* (PDS).

China: *Prof. H. H. Hu* (L 35857).

PACIFIC ISLANDS:

Japan: Iwanai, on rotten wood, July 12, 1916, *A. Yasuda, 7611* (PDS); Nayege, on dead *Pavonia cuspidata*, Aug. 1912, *Takisanjo Mikava* (L 10881); Sendai, May 1913, *A. Yasuda* (L 10880); Sakawa, Tosa, May 1919, *Prof. T. Yoshinaga* (L 10817).

Island of Timor: on trees, 1910, *M. Ferreina* (F).

AUSTRALIA: Victoria, on dead stump of dogwood, Oct. 1911, *Jas. Wilson* (L 10878).

2. Daldinia occidentale Child, sp. nov.

Pl. 27, fig. 6; pl. 28, fig. 3; pl. 32, fig. 4.

Stromata hemisphaeroidea vel subglobosa, sessilia, raro substipitata, carbonacea, plerumque solitaria, raro confluentia, 2.5–8 x 2–7 x 1–3.5 cm.; ectostromatibus tenuibus fragilibusque, primum "Hay's Brown" deinde "Deep Vinaceous Brown" demum obscure atris vel aereo-atris; entostromatibus fibroso-nemorosis, persistentibus, zonatis, zonis subaequalibus, zonis pallidioribus "Drab," "Tawny Olive Cinnamon," "Hair Brown" vel saepius "Benzo Brown," mollibus vel nemorosis, persistentibus, zonis obscurioribus "Bone Brown," "Fuscous" vel atris; peritheciis monostichis vel polystichis, irregulariter pyriformibus, 518–1554 x 185–518 μ; ostiolis punctiformibus vel minute papillatis, plerumque papillatis; sporidiis fuscis, ellipsoideis vel inaequilateraliter ellipsoideis, (9.6)–12.8–(19.2) x (4.8)–6.4–(8)–(9.6) μ.

Stromata hemispherical to subglobose, sessile or rarely substipitate, carbonaceous, usually single or occasionally confluent, 2.5–8 x 2–7 x 1–3.5 cm. Ectostroma at first "Hay's Brown," then "Deep Vinaceous Brown" and finally dull black or shiny

bronze-black, thin, extremely carbonaceous and brittle, cracking off and exposing the tips of the perithecia. Entostroma fibrous-woody, persistent, conspicuously zonate, the zones subequal, the darker ones "Bone Brown" or brownish-black, alternating with lighter zones of "Drab," "Tawny Olive Cinnamon," "Hair Brown," or usually "Benzo Brown" or "Fuscous," soft to woody, persistent. Perithecia monostichous, less frequently polystichous, irregularly pyriform, 518–1554 x 185–518 μ, the wall 14.8–44.4 μ thick; the ostioles punctiform to prominent, mostly prominent. Ascospores ellipsoid to inequilaterally ellipsoid, fuscous, (9.6)–12.8–(19.2) x (4.8)–6.4–8–(9.6) μ. Conidia ellipsoidal, hyaline, borne singly or in whorls, 4–6 x 2–3 μ.

On wood of deciduous trees. Central to western North America, Chile, Tasmania, and New Zealand.

This species, called *Daldinia* "Y" in a previous paper,[28] although closely related to *D. concentrica*, differs from it quite markedly when a series of specimens are studied. Not only are the fruiting bodies unlike, but the asexual conidia are also somewhat larger. In addition to such characters, there is the difference in the physiological behavior of the two species. It is therefore felt that the creation of this new species is fully warranted. See also fig. 4.

Lloyd[29] apparently recognized that the western American material that had been known as *D. concentrica* differed somewhat from the typical form and published it without description as *D. concentrica* forma *californica*. This material was from Washington State where *D. grande* is also found. Another specimen, from Idaho (12379), he labelled *D. confluens* because of its manner of growth. As far as the writer is aware, however, this species has not been published.

Specimens examined:

CANADA:

Ontario: London, on decaying wood, July 1904, *J. Dearness, 2013* (PDS, St), on *Pyrus sambucifolia*, Aug. 7, 1880, *C. G. Pringle, 1161* (F, St 27), *Rev. H. Dupret* (L 12312).

British Columbia: Bendigo, Victoria, June 1918, *E. J. Summers* (L 10806).

[28] Child, M. Ann. Mo. Bot. Gard. **16**: 411–486. 1929.

[29] Lloyd, C. G. Myc. Writings **5**: 23–26. *figs. 1452–1453.* 1919.

United States:

Michigan: Vermilion, on dead birch stump, July 30, 1914. *A. H. W. Povah* (Po 229c), June 27, 1914, *A. H. W. Povah* (Po 617).

Wisconsin: Madison, Oct. 1901, *M. B. Nichols, 4* (St).

Minnesota: Cass Lake, on *Tilia americana,* June 1912, *J. R. Weir* (F); Minneapolis, *Mrs. M. S. Whetstone* (L 10911, 10912, 10930), *Daisy Hone* (L 10913, 10927); Monticello, *E. P. Ely* (L 10928, 10929).

North Dakota: on old log, Feb. 1897, *Prof. V. Reed* (F).

South Dakota: Black Hills, 1903, *von Schrenk,* TYPE (MBG 43121); Custer, on *Quercus* sp., Aug. 1, 1918, *J. R. Weir, 10857* (PDS).

Montana: Boulder, on *Populus trichocarpa,* Sept. 16, 1917, *F. S. Wolpert* (PDS, MBG 58395); Shelby, on standing *Alnus pyrifolia,* Oct. 13, 1911, *J. R. Weir, 6295* (PDS); Melrose, on *Salix* sp., Oct. 6, 1919, *E. E. Hubert* (PDS); Missoula, on *Acer* sp., 1913, *J. R. Weir, 6295* (PDS); Logan, on burned *Betula granulosa,* May 6, 1928, *P. A. Young, 76* (PDS).

Colorado: Eldorado, on dead *Populus tremuloides,* May 1913, *E. Bethel* (L 35856); Grand Mesa, Sept. 11–18, 1929, *F. J. Seaver & P. F. Shope* (NY 567).

Idaho: Boise, on limb of bearing *Pyrus Malus,* April 15, 1916, *E. P. Taylor, 1847* (PDS); Priest River, on fire-killed saplings of *Betula occidentalis,* Aug. 3, 1920, *A. S. Rhoads, 16434, 16440* (PDS), on *Betula papyrifera,* Aug. 28, 1920, *A. S. Rhoads, 16648* (PDS), on *Betula papyrifera,* Aug. 3, 1920, *A. S. Rhoads, 16450* (PDS), on *Alnus tenuifolia,* Aug. 10, 1920, *A. S. Rhoads, 16435* (PDS), on *Alnus tenuifolia,* Aug. 7, 1920, *J. R. Weir, 15055* (PDS), on *Alnus, J. R. Weir* (L 12379), on *Alnus tenuifolia,* June 1914, and Sept. 1914, *J. R. Weir, 2753, 2754, 7444* (PDS); Salmon, on *Populus trichocarpa,* July 15, 1917, *F. S. Wolpert, 7048* (PDS), on *Salix* sp., July 15, 1917, *F. S. Wolpert, 6851* (PDS); St. Maries, on *Populus trichocarpa,* Sept. 9, 1913, *J. R. Weir, 7817* (PDS).

Washington: Bellingham, on *Alnus rhombifolia,* Oct. 1913, *J. R. Weir, 2748* (PDS); Newport, on *Alnus tenuifolia,* Aug. 21, 1920, *A. S. Rhoads, 16613* (PDS); Metaline Falls, on fire-

killed standing *Betula papyrifera*, Aug. 27, 1920, *A. S. Rhoads, 16865* (PDS); Yakima, on prune branch, 1922, *Brooks* (S); Langley, 1922, *J. M. Grant* (PDS); Marysville, on *Alnus*, 1922, *J. M. Grant* (MBG 64435); Sequim, *J. M. Grant* (L 10936, 12378); Spokane, on *Betula papyrifera*, Aug. 8, 1924, *C. R. Stillinger* (L 11796).

California: Monterey, *T. H. MacBride* (Ia 1347), 1894, *T. H. MacBride* (Ia 1348); San Bernardino, May 30, 1899, *S. B. Parish* (L 10932), on fire-killed *Salix* sp., Feb. 13, 1920, *E. Bethel* (L 35855); Santa Paula, on *Citrus* tree, 1912, *H. S. Fawcett* (L 10925).

South America:

Chile: Santiago, on trunks, *M. R. Espinosa* (L 10920); Danquilco, Rio Puelo, on dead trunks, Jan. 1916, *M. R. Espinosa, 28* (PDS).

Tasmania: Aug. 1889, *L. Rodway* (L 10843).

New Zealand: Caversham, *W. A. Scarfe* (L 10899); Christchurch, *Rev. J. Mitchell* (L 11759); Dunedin, *Helen K. Dalrymple* (L 10815); Otira, *E. Cheel* (L 10832); Waikanini, *W. E. Barker* (L 10844), *S. Duncan* (L 10896); Wellington, Island Bay, *Jessie Dunn* (L 10897); without locality, Oct. 1911, *W. E. Barker* (L 10900).

3. **Daldinia grande** Child, sp. nov.

Pl. 27, fig. 8; pl. 28, figs. 7–8; pl. 30, fig. 8; pl. 32, fig. 3.

Stromata sessilia, subhemisphaeroidea, late confluentia, carbonacea, nemorosa, 1.2–14 x 1.5–7.5 x 1–5 cm.; ectostromatibus primum "Dark Vinaceous Brown" deinde obscure atris vel aereoatris, valde fragilibus; entostromatibus dense fibrosis, persistentibus, manifesto zonatis, zonis obscurioribus "Fuscous Brown" vel "Bone Brown," zonis pallidioribus "Drab," "Hair Brown" vel "Benzo Brown," mollibus vel dense fibrosis persistentibusque, 2–3-plo latioribus; peritheciis monostichis vel polystichis, praecipue polystichis, pyriformibus vel subclaviformibus, 518–1850 x 185–740 μ; ostiolis raro punctiformibus, saepe prominentibus, mammiformibus; sporidiis ovoideis vel inaequilateraliter ellipsoideis, dilute fuscis vel atro-fuscis, (8)–14.4–16–(27.2) x (6.4)–8–(11.2) μ.

Stromata sessile, flattened-hemispherical, usually broadly confluent, carbonaceous, woody, 1.2–14 x 1.5–7.5 x 1–5 cm. Ectostroma at first "Dark Vinaceous Brown," finally dull black to bronze-black, extremely brittle. Entostroma densely fibrous, persistent, conspicuously zonate, the darker zones "Fuscous" to "Bone Brown," the lighter zones 2–3 times broader, soft to fibrous, "Drab," "Hair Brown," or "Benzo Brown." Perithecia monostichous or polystichous, pyriform to subclaviform, 518–1850 x 185–740 μ, the walls 14.8–59.2 μ thick; ostioles rarely obsolete or punctiform, usually prominent and mammiform. Ascospores ovoid, ellipsoid to inequilaterally ellipsoid, the ends bluntly rounded, fuscous to deep fuscous, (8)–14.4–16–(27.2) x (6.4)–8–(11.2) μ.

On wood of various deciduous trees. Western United States, Ecuador, Australia, and New Zealand.

This species differs from the preceding in that the perithecia are polystichous as a rule rather than as an exception; the ostioles are more prominent as papillate or mammiform protuberances on the surface of the stroma; and the spores are somewhat larger and more bluntly rounded at the ends.

Specimens examined:

UNITED STATES:

Minnesota: Cass Lake, on roots of living *Tilia americana, J. R. Weir, 2752* (PDS).

Montana: Melrose, on *Salix* sp., Oct. 6, 1919, *E. E. Hubert* (PDS).

Colorado: on aspen, *Ernest Knäbel* (L 10826, 10944).

Arizona: Soldiers Camp, Coronado National Forest, on dead *Populus tremuloides, G. G. Hedgcock* (L 11769).

Washington: Bellingham, on *Acer macrophyllum*, 1914, *J. R. Weir, 2755* (PDS); Langley, 1922, *J. M. Grant* (PDS); without locality, 1912, 1916, *T. H. MacBride* (Ia).

California: Sacramento, on cottonwood stump, April 1909, *Miss Sutcliff* (L 10941); San Bernardino, on *Salix*, May 24, 1920, *E. Bethel* TYPE (Sh); San Francisco, Golden Gate Park, on *Acacia* sp., Oct. 16, 1910, *W. T. Swingle* (PDS); Victorville, on dead area of *Salix Gooddingii*, April 4, 1918, *E. Bethel* (L 11768); southern California, 1899, *S. B. Parish* (Ia 1346).

South America:
Ecuador: Quito, *Rev. L. Mille* (L 10829); *N. Nuñez* (L 10831).
Australia: East Caulfield, *J. T. Paul* (L 10838, 10919).
New Zealand: Christchurch, *J. Mitchell* (L 11795); Dunedin, *E. P. Northcroft* (L 12296); Tapanui, Otago, *R. G. Robinson* (L 10889) Waikawa, *W. E. Barker* (L 10901).

4. **Daldinia Eschscholzii** (Ehrenb.) Rehm, Ann. Myc. **2**: 175. 1904.

Sphaeria Eschscholzii Ehrenberg, Fungi Cham. 89. *pl. 18, fig. 8.* 1820.
Daldinia concentrica var. *Eschscholzii* (Ehrenb.) Rehm, Ann. Myc. **2**: 175. 1904.
Daldinia vernicosa f. *microspora* Starbäck, Kongl. Svensk Vet-Akad. Handl. III. **27**[9]: 6. 1901, sense of Theissen.
Daldinia concentrica var. *microspora* (Starb.) Theissen, Ann. Myc. **7**: 3. 1909.
Daldinia corrugata Patouillard & Hariot, Bull. Soc. Myc. France **22**: 120. 1906.
Daldinia argentinensis f. *sessilis* Spegazzini, of authors in part, Anal. Mus. Nac. Buenos Aires III. **12**: 345. 1909.
Daldinia luzonensis Rehm, Philippine Jour. Sci. **8**: 260. 1913.
? *Hypoxylon stratosum* Sacc. Syll. Fung. **9**: 544. 1891.
? *Daldinia stratosa* Sacc. Syll. Fung. **22**: 327. 1913.

Pl. 26, fig. 5; pl. 27, fig. 5; pl. 28, fig. 5; pl. 29, figs. 3, 5–6, 8; pl. 31, fig. 1; pl. 33, fig. 3.

Stromata subhemispherical, flattened, solitary or confluent, sessile or substipitate, usually smooth, rarely deeply wrinkled or convolute, 1.5–7 x 1.7–5.5 x .8–4 cm. Ectostroma thin, brittle, usually "Anthracene Purple," "Dark Vinaceous Brown," or "Sorghum Brown," later becoming black, dull or laccate. Entostroma soft to pithy, but persistent, conspicuously concentrically zonate, the lighter zones "Pale Mouse Gray," "Mouse Gray," "Light Drab," "Pale Drab," "Smoke Gray," "Tilleul Buff," "Hair Brown," or "Benzo Brown," radiate-fibrous and two or

more times broader than the darker "Bone Brown" or "Fuscous" zones. Perithecia usually monostichous, very rarely polystichous, closely appressed, claviform, 518–1628 x 148–518 μ, the walls 14.8–51.8 μ thick. Ostioles distant, usually obsolete to punctiform, rarely prominent. Ascospores amber-colored to brown, inequilaterally ellipsoid, the ends usually lighter-colored and refractive, (8)–11.2–(14.4) x 4.8–(6.4) μ.

On the wood of various deciduous trees. Tropical or subtropical.

This species is closely related to *Daldinia concentrica*, in that it has a dense, dark-colored entostroma, but aside from this point there is little in common, for the spores are smaller and the perithecia, entostroma, and other characters show evident differences in appearance. However, during the examination of a large number of specimens, it was found that when the frequency of spore sizes was plotted the median fell at 11.2 x 4.8 μ, but within this grouping there were nevertheless four rather distinct classes of spore sizes of the following frequency: 39 collections of which the median size was 11.2 x 4.8 μ; 17 collections at 11.2 x 6.4 μ; 16 collections at 12.8 x 6.4 μ; 9 collections at 12.8 x 4.8 μ. Although there is such a variation in spore size, it is not singular that a species with such a wide distribution should show some variation.

The type of *D. corrugata* from Africa was not available for examination, but several specimens so classified in the Lloyd herbarium proved to be small specimens of *D. Eschscholzii*. Infolding of the stroma, alone, does not seem to be a character of sufficient taxonomic value to warrant its use in the creation of a new species. In the original description, Patouillard and Hariot describe the entostroma as white and zonate. None of the specimens seen by the writer has a truly white entostroma, but rather a light gray one. This point may be one that depends on the personal equation, and hence should not be too strongly stressed. According to Lloyd,[30] this African species is quite close to *D. concentrica* in spite of its corrugated surface. The writer feels that this species should be considered a synonym of *D. Eschscholzii*. Similarly, *D. luzonensis*, of which the type and co-type

[30] Lloyd, C. G. Mycological Writings **5**: 25. *fig. 1454*. 1919.

material were examined, proved to be synonymous with this species.

Specimens examined:

Exsiccati: Klotzsch, Herb. Viv. Myc., 162; Maire, Mycoth. Bor.-Afr., 120; Rehm, Ascomyceten, 1718; Roumeguére, Fungi Select. Exsicc., 5140, 5829; Smith, C. L. Cent. Amer. Fungi, 33; Wright, Fungi Cub. Wright., 818.

United States:

Florida: MacLendons I. (probably Florida), on *Citrus decumana* stump, *W. T. Swingle, 1697* (F, MBG); Gainesville, *N. L. T. Nelson* (L 10923, 10942, 12179), June 4, 1930, and Aug. 1930, *E. West* (MBG); Victoria, Orange Co., on felled maple, July 20, 1919, *C. H. Baker, 557* (L); on grubbed orange stump, Dec. 20, 1923, *A. S. Rhoads* (L 11771); on *Citrus Bigaradia*, April 25, 1892, *W. T. Swingle* (PDS).

Louisiana: St. Martinsville, on rotten hardwood limb, June 24, 1911, *C. J. Humphrey* (L 10809); Pointe à la Hache, on decaying log, July 1886, *Rev. A. B. Langlois, 825* (F), Aug. 1896, *Langlois, 829* (PDS).

Texas: Feb. 23, 1921, *N. L. T. Nelson, 1* (L 10814, St); Austin, Dec. 1930, *G. W. Goldsmith* (T).

Mexico: Vera Cruz, *C. L. Smith, 1351* (Ia).

Central America:

Nicaragua: Los Amates, Feb. 20, 1907, *W. A. Keller* (PDS); Ometepe, Jan.–Feb. 1893, *C. L. Smith, 33* (F); Castillo Viejo, Feb.–Mar. 1893, *C. L. Smith, 78* (PDS).

Honduras: La Ceiba, May 1923, *C. M. Sutter* (MBG 18576); Tela, on dead tree trunks, Jan. 17, 1923, *O. A. Reinking* (L 12294).

West Indies:

Cuba: Ciego, on dead roots, Dec. 5, 1924, *J. R. Weir, 66519* (PDS), on dead roots in cane field, Dec. 5, 1924, *J. R. Weir, 6519* (F); Consolacion, on fallen trunk, Dec. 1, *C. Wright, 818* (F); Guantanamo Oriente, July 1920, and Dec. 28, 1920, *B. Hioram, 16579, 17769* (PDS); Palo Seco, on *Citrus*, Dec. 13, 1915, *J. A. Stevenson, 2757* (PDS); Santa Clara, Nov. 23, 1924, *J. R. Weir* (S); Santiago de las Vegas, Dec. 10, 1915, *J. R. Johnston, 1335* (S); Trinidad, Nov. 24, 1924, *J. R.*

Weir, 64816 (PDS); without locality, *C. G. Lloyd* (L 10836, 10839, 10847).

Porto Rico: Pueblo Viejo, on rotten stumps, Jan. 1915, *J. A. Stevenson, 2525* (PDS); Rio Piedras, on logs, Dec. 4, 1915, *B. Fink, 657* (PDS); San Juan, on dead *Citrus* stump, March 1, 1917, *H. E. Thomas, 8* (S); without locality, Feb. 30, 1919, *F. S. Earle, 247* (S), Dec. 6, 1920, *F. S. Earle, 309* (PDS).

Jamaica: *Wm. Chadwick* (L 10868).

Bahamas: *L. J. K. Brace* (L 10813, 10830, 12302, 12406); *A. D. Machado* (L 12385).

St. Croix: Jolly Hill, 1905–06, *C. Raunkiaer, 1711a* (B).

South America:

Argentina: La Plata, on *Quercus ruber*, Dec. 1923, *J. R. Weir* (PDS); Rio Pescado, Jujuy, on decayed trees, March 1905, *Spegazzini* (A), (1).[31]

Bolivia: Tatarenda, Gran Chaco, March 4, 1902, *Robt. E. Fries, 408* (St).

Brazil: *J. Rick* (L 12303); Leno Agul (?), 1923, *J. Rick* (L 10851); Bahia, June 1915, *C. Torrend, 15811* (PDS); Matto Grosso, Cuyabá, May 13, 1894, *G. O. Malme, 0595* (St).

Europe:

France: Dijon, Côte d'Or, 1904, *M. Barbier* (L 10841).

Germany: Nassau, in forest of Hattersheim, *Fuckel, 305* (F, PDS, St).

Africa:

Algiers: on trunk of dead *Eucalyptus*, Feb. 3, 1913, *R. Maire, 120* (PDS, St); on trunks, Oct. 1889, *L. Trabut, 5140* (F); Coomassee, *T. Hunter* (L 10846).

Liberia: on burnt stump, July 25, 1926, *D. H. Linder, 167* (F); Mt. Barclay, on charred stumps and logs, July 20, 1926, *D. H. Linder* (F); *T. Hunter* (L 10823).

Gold Coast: Abeesé, *R. H. Bunting* (L 10834).

Nigeria: 1917, *Farquharson, 5* (PDS).

São Thomé I.: on fallen trunks, *O. Möller, 5829* (F).

Congo: (L 10867); *F. Theissen* (L 10938).

[31] Since the type collection was a mixed collection, having no number, the author has separated the material and put it into packets bearing the numbers 1, 2, and 3. See footnote on page 477.

Angola: Loanda, on dead trees, March 1918, *J. Gossweiler* (L 10849); *J. Gossweiler* (L 12376).

Union of South Africa: Stellenbosch, *Miss A. V. Duthie* (L 10904); Pretoria, *A. J. T. Janse* (L 10875).

Mozambique: Tiembo, April 1913, *A. Truz, 142* (St).

Tanganyika Territory (Dutch East): Tanga, *A. Karansek* (L 10862).

Uganda Protectorate: on logs, Feb. 19, *R. A. Dammer, 1442* (PDS).

Zanzibar: *Chas. A. O'Connor* (L 12180).

MADAGASCAR: *Henri Perrier de la Bathie* (L 10856).

REUNION ISLAND: *E. Dupont* (L 10890).

MAURITIUS ISLAND: *Chas. A. O'Connor* (L 10891).

ASIA:

Syria: Beyrouth, *Rev. A. Boulomoy* (L 10858).

India: Pusa, on old wood, May 14, 1906, *Inayat* (St 1121), on wood, Feb. 1923, *Azmabullah Khan* (PDS), on *Dalbergia Sissoo*, Feb. 1, 1917, *E. J. Butler* (PDS), on same host, Aug. 1910, *J. F. Dastur* (St 1122); Bombay, on old wood, Oct. 3, 1908, *H. M. Chibber* (St 1118); Madras, Oct. 1911, *J. Hornell* (L 10845); Nagpur, (on living ?) *Citrus Aurantium*, Sept. 19, 1908, *Paudit* (St 1115); Burma, on old wood, Jan. 12, 1908, *E. W. Buttel* (St 1120).

Malay Peninsula: Negri Sembilan, on dead *Hevea*, Nov. 22, 1922, *R. E. Holttum* (L 12806); Singapore, on dead log, Dec. 29, 1919, *T. F. Chipp* (L 10821), on dead rubber stump, Nov. 1923, *Abul Vadir* (L 12297).

Bonin Island: 1853, *C. Wright, 56* (F).

China: Kuling, Prov. of Kiangsi, Sept. 8, 1929, *Chung, 4355* (F).

PHILIPPINE ISLANDS: Capez, Panay, Jan. 10, 1904, *E. B. Copeland* (L 10802); Palawan, July 1912, *E. Fenix, 15613* (L 12407, PDS); Leyte, Palo, Jan. 1906, *A. D. E. Elmer* (MBG 705734); March 1909, *A. Celestina, 21* (St); Prov. of Bataan, Luzon, Nov. 1912, *P. W. Graff* (L 10803); Antipalo, Luzon, Oct. 1912, *M. Ramos* (St 16824, as *D. concentrica* var. *microspora*, authentic material, L 10801); Mt. Maquiling, Luzon, on rotten trunks, Jan. 31, 1914, *C. F. Baker, 2723* (St), on dead

wood, Oct. 4, 1920, *S. Bacal* (L 10173, PDS), on dead wood, Oct. 3, 1920, *R. Habaluijas* (L 10598), Nov. 1920, *S. Mariano* (L 10686, PDS), on dead wood, Oct. 1920, *O. A. Reinking* (L 10613, PDS), Oct. 3, 1920, *C. Serrano 9934* (L 12182), Oct. 3, 1920, *A. Reyes* (L 10800), on *Garcinia* sp., Nov. 7, 1920, *A. Reyes* (L 10950, PDS), on dead wood, Oct. 1920, *G. Zabella* (L 10919, PDS), Dec. 1919, *H. S. Yates* (L 10587), July 5, 1919, *J. Corrales* (L 10797); Prov. of Nueva Vizcaya, Luzon, Jan. 1913, *McGregor* (PDS 20274); Prov. of Tayabas, Luzon, 1916, *H. S. Yates* (MBG 59960); Manila, *Father Sanchez* (L 11878, St), on *Hevea brasiliensis*, Oct. 1917, *H. S. Yates 96* (PDS); Isla Cruz, Prov. of Laguna, Luzon, on *Citrus decumana*, Feb. 2, 1919, *N. Reyes* (L 10805); Prov. of Calauan, Laguna, on dead wood, Feb. 13, 1921, *F. Bernardo* (L 12292), *O. A. Reinking* (L 12291); Prov. of Rizal, Luzon, Oct. 12, *M. Ramos* (St); Butuan, Subprov. Mindanao, March–July, 1911, *C. M. Weber, 1257* (F); Los Baños, Prov. of Laguna, Luzon, on dead wood, Nov. 7, 1920, *A. Abesans* (L 10852), on rotten trunks, Dec. 1, 1912, TYPE collection of *D. luzonensis* Rehm, *C. F. Baker* (MBG 12465, L 12401), Oct. 2, 1919, *H. Cuzner* (L 10798), on decaying wood, Sept. 25, 1919, *G. O. Ocfemia* (PDS 5944), on bark of *Tamarindus Medicus*, Aug. 5, 1913, *Evaristo, 1562, 1568* (St), on dead wood, March 1919, *E. Quisunging* (PDS 3598), on decaying wood, Sept. 25, 1919, *G. O. Ocfemia* (PDS, Po 229b, L 10799); Benquet, Los Baños, on *Polyalthia, O. A. Reinking, 11370* (PDS), on *Celtis*, April 2, 1921, *O. A. Reinking, 11262* (PDS), on dead wood, April 2, 1921, *O. A. Reinking* (L 12290, 12293), on *Dipterocarpus*, April 2, 1921, *O. A. Reinking, 66606* (PDS), on *Macaranga*, April 2, 1921, *O. A. Reinking, 11350* (PDS), on *Citrus decumana*, March 2, 1919, *N. Reyes, 3575* (PDS); Basilan I., Isabela, Dec. 1919, *H. S. Yates* (L 10587).

EAST INDIES:

Java: Cheribon, on *Tamarindus indicus*, 1920, *J. C. van der Meer Mohr* (S), 1922, ex *H. Bigoriensis* (MBG); Pati, on *Dalbergia latifolia* (dead), March 1920, *C. Hartley, 19861* (PDS); Buitenzorg, 1913, *W. P. Thompson* (F), *C. Hartley*,

19661 (PDS); Madiun, Jan. 29, 1922, *Dr. T. A. Tengwall* (L 12299).

Timor Island: *G. Bresadola, 45* (PDS), on trunks, 1916, *M. Feniera, 42* (PDS).

Australia: Sydney, *E. Cheel* (L 10827), *W. W. Froggatt* (L 10902), *J. B. Cleland* (L 10876); Grantville, *F. F. Paul* (L 10892); without locality, Dec. 1919, *H. S. Yates* (L 10585, 12409).

Tasmania: *L. Rodway* (L 10816).

Pacific Islands:

Samoa: 1904–05, *C. G. Lloyd* (L 10859, 10860, 10869, 12400, 12298); Apiaberg, on *Citrus Aurantium*, May 1905, *Dr. K. & E. Rechinger, 1718* (B, F, PDS, St), authentic material; 1904–05, *W. A. Setchell & H. E. Parks* (L 12298).

Guam: *Peter Nelson* (L 12387).

Tahiti: Tataa, on dead cocoanut, May, 1922, *H. E. Parks* (L 12394), on rotting *Papaya*, June 1922, *H. E. Parks* (L 12295).

5. **Daldinia Bakerii** Lloyd, Myc. Writings **5**: 25–26. 1919, char. emend.

Daldinia Eschscholzii (Ehrenb.) Rehm, of authors.

Pl. 31, fig. 5.

Stromata subhemisphaeroidea vel subsphaeroidea, plerumque convoluta, solitaria vel confluentia, sessilia vel substipitata, levia vel rugosa plicataque, 1.5–4.5 x 2–4 x 1.2–2.3 cm.; extostromatibus carbonaceis subfragilibus, "Deep Vinaceous Brown" vel "Deep Livid Brown" deinde fulgidis vernicosisque, atris; entostromatibus mollibus, contextis vel fibrosis, persistentibus, manifesto zonatis, zonis obscurioribus "Benzo Brown," "Bone Brown" vel "Fuscous," zonis pallidioribus "Pallid Mouse Gray," "Dark Mouse Gray," "Smoke Gray" vel "Hair Brown," 2–3 plo latioribus; peritheciis plerumque monostichis, raro polystichis, plerumque late claviformibus, 666–8510 x 148–592 μ; ostiolis prominentibus, dense aggregatis, saepe ad bases stromatum majoribus; sporidiis inaequilateraliter ellipsoideis, intus ascos obliquiter monostichis, dilute fuscis vel atro-fuscis, (9.6)–14.4–(24.0) x (4.8)–6.4–(11.2) μ.

Stromata subhemispherical to globose, usually convolute, single or confluent, sessile to substipitate, smooth or wrinkled and infolded, 1.5–4.5 x 2–4 x 1.2–2.3 cm. Ectostroma carbonaceous, somewhat fragile or brittle, "Deep Vinaceous Brown" to "Deep Livid Brown," later becoming black, shining, and laccate. Entostroma soft, pithy to fibrous, persistent, zonate, the lighter zones "Pallid Mouse Gray," "Dark Mouse Gray," "Smoke Gray" to "Benzo Brown," 2–3 times wider than the darker "Benzo Brown," "Bone Brown," or "Fuscous" zones. Perithecia usually monostichous, more rarely polystichous, mostly broadly claviform, widest at apices, but slightly tapering at the base, 666–8510 x 148–592 μ, the wall 22.2–51.8 μ thick; ostioles prominent, close together, frequently more prominent at the base of the stroma. Spores inequilaterally ellipsoid, obliquely uniseriate in the ascus, amber-colored to dark brown, with or without refractive ends, (9.6)–14.4–(24.0) x (4.8)–6.4–(11.2) μ.

On wood of various deciduous trees. Asia, Africa, Philippine Islands, Australia, Costa Rica, Porto Rico, Mexico, West Indies, and South America.

This species is closely related to *D. Eschscholzii*, but because of the wider range in the size of the spores and also their generally larger size, it is considered to be distinct.

Specimens examined:

MEXICO: Mexico City, on *Fraxinus* (*Berlandieriana* ?), June 25, 1924, *Dr. A. Dampf, 6350* (PDS); without locality, *W. A. Murrill, 0313* (L).

CENTRAL AMERICA:

Costa Rica: Estrella Valley, on decayed prostrate log, July 1, 1921, *Paul V. Siggers* (L 12178).

WEST INDIES:

Porto Rico: on old stump, Dec. 7, 1920, *F. S. Earle, 301* (S).

SOUTH AMERICA:

Argentina: Chaco, Prov. of Jujuy, Oct. 6, 1901, *R. E. Fries* (St 053).

Bolivia: Tarija, Jan. 21, 1902, *R. E. Fries* (St 246).

Chile: Chaparro, Limache, Sept. 23, 1927, *Garaventa* (F).

AFRICA:

Natal: Pretoria, Aug. 1918, *J. M. Sim* (L 10824); without locality, *A. J. T. Janse* (L 10870).

Asia:

Asia Minor: Turkey, Palu, Aug. 1923, *Remp* (PDS).

India: Saharanpur, *Wm. Golden* (L 10857); Cuttack, *Jages Ray* (L 10837); Bengal, *S. Hutchings* (L 10855, 10842); Dadabetta, Oct. 1911 (L 10866); Darjeeling, *G. H. Cave* (L 10863); Pusa, on old wood, April 8, 1906, *Inayat* (St 1124); Cherra Punji, on old wood, May 15, 1905, *E. W. Butler* (St 1119); Nilgiri, on old wood, Aug. 1902, *C. A. Barber* (St 1117).

Philippine Islands: Luzon, Prov. of Tayabas, Dec. 1916, *H. S. Yates, 25604* (F); Subprov. Panai, Jan. 1915, *M. S. Clemens, 9246* (F); Subprov. Benquet, Jan. 1915, *M. S. Clemens* (MBG 59959); Batangas, on dead branch of *Citrus nobilis*, Oct. 17, 1917 (S); Los Baños, Prov. of Laguna, on dead wood, May 6, 1917, *F. Collado* (PDS 3632).

Australia: Sydney, 1901, *R. T. Baker*, type (L 12377).

6. **Daldinia Gollani** Hennings, Hedwigia **40**: 339. 1901.

Daldinia cognata Patouillard & Hariot, Jour. de Bot. **17**: 15. 1903.

Hypoxylon Hibisci Hennings, Hedwigia **47**: 259. 1908.

Daldinia platensis Spegazzini, Anal. Mus. Nac. Buenos Aires III. **12**: 345. 1909.

Daldinia Hibiscus (Henn.) Lloyd, Myc. Writings **6**: 901. *fig. 1587*. 1919.

Pl. 27, fig. 7; pl. 31, fig. 6.

Stromata flattened-hemispherical, turbinate to subglobose, sessile to substipitate, 1–3.5 x 1–4 x .8–1.7 cm. Ectostroma usually rugose, thin, brittle, "Hay's Brown," "Brownish Drab," "Dark Vinaceous Brown," "Anthracene Purple," later dull or laccate and black. Entostroma soft, pithy or fibrous, persistent, concentrically zonate, the lighter zones "Tilleul Buff," "Hair Brown," "Gray White," "Drab Gray," or "Benzo Brown," 1–6 times wider than the darker "Bone Brown" or "Fuscous" zones. Perithecia usually monostichous, rarely polystichous, globose, 444–1250 x 162–518 μ, the walls 22.2–51.8 μ thick; ostioles distant, obsolete, punctiform or slightly papillate. Ascospores inequilaterally ellipsoid, acutely rounded at the lighter colored ends, amber to brown, (6.4)–9.6–(12.8) x (3.2)–4.8–(6.4) μ.

On wood of deciduous trees. Jamaica, Brazil, Argentina, New Caledonia, India, and the Philippine Islands.

This species differs from all others in the *D. concentrica* group by having subglobose perithecia, and conspicuously acutely rounded spores of relatively small size.

Specimens examined:

WEST INDIES:

Jamaica: Balaclava, May 4, 1909, *A. E. Wight, 340* (F).

SOUTH AMERICA:

Brazil: Rio Grande do Sul, Lageado, 1925, *Rick* (PDS 19811); without locality, *Rick* (PDS, L 12383, 12389); Matto Grosso, Sierra da Chapada, June 20, 1894, *G. O. Malme, 5* (St).

Argentina: La Plata, on trunks, Dec. 28, 1906, *Spegazzini*, TYPE of *D. platensis* (A).

ASIA:

India: Siwalik Range, 1600 ft., on *Ficus Carica,* 1900, *W. Gollan, 269,* TYPE (B).

PHILIPPINE ISLANDS: without data (L 12408), probably TYPE of *D. Hibiscus; E. D. Merrill* (L 12403).

NEW CALEDONIA: 1901, *Desmazieres,* TYPE of *D. cognata* (L 12374).

7. **Daldinia caldariorum** Hennings, Verh. Bot. Ver. Prov. Brandenb. **20**: 158. *pl. 2, fig. 14.* 1897.

Pl. 26, figs. 6–7; pl. 31, fig. 2.

Stromata subglobose, laterally compressed, 5–12 x 5–12 x 5 mm. Ectostroma thin, brittle, at first "Hay's Brown" or "Dark Vinaceous Brown," finally shining black. Entostroma definitely zonate, the lighter zones "Hair Brown," soft, compact, persistent, twice as broad as the "Fuscous" zones. Perithecia monostichous, irregularly pyriform, 666–814 x 296–444 μ; the walls 29.6–37 μ thick. Ostioles obsolete. Ascospores brown, inequilaterally ellipsoid to ellipsoid, (9.6)–11.2–(14.4) x 4.8–(6.4) μ.

On wood of deciduous trees. Germany and Brazil.

Specimen examined:

GERMANY: Berlin Botanical Garden fern house, Dec. 1887, *P. Hennings* TYPE (B). Hennings[32] also reports the occurrence of this species from Brazil.

[32] Hennings, P. Broteria **5**: 50. 1906.

8. **Daldinia loculata** (Lév.) Sacc. Syll. Fung. 1: 394. 1882.
Sphaeria loculata Léveillé, Ann. Sci. Nat. Bot. III. 3: 47. 1845.
Daldinia intermedia Lloyd, Myc. Writings 5: 23–26. 1919.
Daldinia Murrillii Lloyd, Myc. Writings 6: 901. *fig. 1588.* 1919.

Pl. 26, figs. 3–4; pl. 30, fig. 4; pl. 32, figs. 1–2.

Stromata globose above, usually rugose, .3–2 x .5–2.3 x .6–2.5 cm., sharply constricted below the perithecia-bearing head to a definite cylindrical stipe, rarely substipitate, usually single, rarely confluent. Ectostroma thin, moderately brittle, at first "Hay's Brown," "Brownish Drab" or "Deep Vinaceous Brown," later becoming black, dull or laccate. Entostroma conspicuously zonate, densely fibrous, persistent, the lighter zones "Benzo Brown," "Hair Brown," or "Fuscous," "Mouse Gray" or "Smoke Color," 2–5 times wider than the darker "Bone Brown" zones. Perithecia monostichous or polystichous, pyriform to irregularly subclaviform, subdistant, 185–518 x 444–1480 μ; ostioles obsolete, punctiform, to rather prominent, distant to subdistant. Ascospores navicular to inequilaterally ellipsoid, amber-color to brown, the ends often lighter in color and refractive, (9.6)–12.8–(19.2) x (4.8)–6.4–(8) μ.

On wood. United States, Mexico, West Indies, Japan.

Of the species with the dense, persistent entostroma, only this one has a definite stipe, and by this character it can be readily recognized.

Specimens examined:

UNITED STATES:

New York: Menaud, 1845, *J. H. Léveillé*, TYPE (P).

South Carolina: Claw Hammer Cove, Pisgah, on *Hicoria alba*, Aug. 15, 1924, *G. G. Hedgcock* (L 11767); on dead limbs of *Ostrya virginica*, *H. W. Ravenel* (F).

Ohio: Preston, 1896, *A. P. Morgan* (Ia); Akron, *G. D. Smith* (L 12404).

Michigan: East Lansing, *E. A. Bessey* (L 12329).

Wisconsin: Cleveland, *Chas. Golosel* (L 12405).

Minnesota: Princeton, on dead *Carpinus caroliniana*, Sept. 26,

1911, *C. J. Humphrey* (L 12305); Minneapolis, *Mary S. Whetstone* (L 12307).

Iowa: Delaware Co., *B. Shimek* (Ia 1352).

Mexico: *W. A. Murrill*, TYPE of *D. Murrillii* (L 12402).

West Indies: Jamaica, 1908 and 1909, *A. E. Wight* (F).

Asia:

Japan: Kobe, *J. E. A. Lewis* (L 11793); Sendai, Mt. Akagi, Oct. 9, 1911, *A. Yasuda* (L 12167).

9. **Daldinia vernicosa** (Schw.) Cesati & de Notaris, Comm. della Soc. Critt. Ital. **1**: 198. 1863.

Sphaeria concentrica var. *stipitata* Pers. Syn. Meth. Fung. **1**: 8. *pl. 1. figs 3–4.* Göttingen, 1801.

Hypoxylon concentricum var. *obovatum* Fries, Syst. Myc. **2**: 331. 1823.

Sphaeria vernicosa Schw. Jour. Acad. Nat. Sci. Phila. **5**: 9. *pl. 1. fig. 2.* 1825.

Sphaeria (concentrica) cingulata Lév. Ann. Sci. Nat. Bot. III. **3**: 47. 1845.

Hypoxylon (Pulvinatae) vernicosum (Fr.) Berk. & Curt. Proc. Linn. Soc. Bot. **10**: 384. 1867.

?*Daldinia cingulata* (Lév.) Sacc. Syll. Fung. **1**: 395. 1882.

Daldinia fissa Lloyd, Myc. Writings **7**: 1313. *pl. 306, fig. 2986.* 1924.

Pl. 26, fig. 1; pl. 28, fig. 1; pl. 30, figs. 2, 5; pl. 33, fig. 2.

Stromata subturbinate to turbinate, contracted below into a distinct rugose stipe with annular zones externally visible, stromata usually single, occasionally confluent, fragile, .6–3.5 x .5–2.5 x .8–2.5 cm. Ectostroma thin and carbonaceous, brittle, at first "Hay's Brown, "Cameo Brown," "Van Dyke Brown," "Fuscous" or "Dark Vinaceous Brown," finally shiny or laccate and black. Entostroma conspicuously zonate, the lighter zones usually gray-white, yellowish gray, or "Drab," fibrous, collapsing and loculate, 2–4 times broader than the darker and more persistent "Bone Brown" to black zones. Perithecia monostichous or polystichous, ovoid-oblong to subglobose, 518–1258 x 185–

666 μ, the wall 14.8–37 μ thick. Ostioles punctiform to somewhat prominent. Ascospores usually brown or dark brown, the ends obtusely rounded, (8)–11.2–12.8–(17.4) x (4.8)–6.4–(8) μ. Conidia single or in whorls, subglobose to ovoid, hyaline, 2.4–3.2 x 2.4–3.2 μ.

On wood, frequently charred, of living and dead deciduous trees. Cosmopolitan.

The substipitate, turbinate stroma, together with the light colored entostroma, marks this species.

Daldinia cingulata and *D. fissa* appear to be ill-advised species which were founded on large or abnormal specimens. The writer could find no characters other than that of size to separate the latter species from *D. vernicosa.* From the early descriptions and illustrations, *H. concentricum* var. *obovatum* is clearly synonymous with *D. vernicosa,* and as such it has been pretty generally accepted, although the writer has found some specimens of *D. Eschscholzii* which have been determined as this variety. *Sphaeria concentrica* var. *stipitata* is apparently synonymous with *D. vernicosa.* Plate figures show definite stipitate ascocarps and a marked differentiation of color in the zonation, which was evidently intended to show light gray or white loculate zones alternating with more dense dark ones. The ascocarps of *D. concentrica* are sessile or substipitate and the zones are shades of brown and are more dense than those of *D. vernicosa.*

Specimens examined:

EXSICCATI: de Thümen, Fungi Austr., 1154; Ell. & Ev., Fungi Columb., 735; Ellis, N. Am. Fungi, 166; Fairman, Mycoth. Fairmani, 4415; Fuckel, Fungi Rhenani, Suppl., 2468; Linhart, Fungi Hung., 180; Roumeguére, Fungi Gall. Exsicc., 3946; Sacc. Mycoth. Veneta, 153; Sydow, Mycoth. Marchica, 3469.

UNITED STATES:

New Hampshire: Meredith, Sept. 1924, *Miss Ann Hibbard* (L 11876).

Vermont: Middlebury, Oct. 1910, *C. G. Lloyd* (L 12325).

Massachusetts: Cambridge, on *Fagus,* Sept. 1915, *A. P. D. Piguet, 10* (F); Canton, on *Tupelo,* Oct. 19, 1929, *D. H. Linder* (Li).

Connecticut: Sand Beach, *Miss Ruby Wilbur* (L 12315).

New York: Lyndonville, on old birch poles, autumn, 1920 or 1921, *C. E. Fairman* (S 4415); Syracuse, Aug. 1911, and Sept. 11, 1913, *L. H. Pennington* (L 12319 and 12321).

New Jersey: Newfield, on dead white oak saplings, Sept. 1899, *Ellis* (F), Ellis, N. Am. Fungi, on dead shrubs and trees, *Ellis* (PDS 1175).

Pennsylvania: State College, on dead *Quercus alba*, Aug. 31, 1916, *A. S. Rhoads* (L 11770); Philadelphia, Aug. 31, 1904, *Mrs. G. M. Dallas* (L 12330).

Maryland: Glen Echo Heights, on *Liriodendron tulipifera*, April 19, 1925, *G. G. Hedgcock* (L 11875); Hyattsville, on *Quercus*, Nov. 1, 1885, *F. L. Scribner* (PDS), Nov. 1, 1887, *F. L. Scribner, 441* (PDS); Holland Point, on *Ilex opaca*, March 25, 1923, *A. Marlowe & E. K. Cash* (PDS), on *Cornus florida*, *E. K. Cash* (PDS); Scotland, St. Marys Co., on dead *Ilex opaca*, Sept. 2, 1923, *S. F. Blake* (PDS); Cabin John, on fire-killed *Acer rubrum*, Oct. 21, 1917, *A. S. Rhoads* (L 12386).

District of Columbia: Washington, on dead wood, March 26, 1916, *W. Piper* (PDS), on *Fagus atropunicea*, Aug. 30, 1914, *R. G. Pierce* (PDS 8240); *Dr. A. Hrdlicka* (L 12323).

Virginia: Arlington, on *Quercus*, *Hicoria*, *Liriodendron*, and *Sassafras*, Feb. 22, 1927, *C. L. Shear* (S 5586), on wild grape vine, Dec. 11, 1911, *J. R. Weir, 2760*, (PDS); Clarendon, on fire-scarred *Liriodendron*, Aug. 28, 1926, *J. R. Weir* (PDS), on *Diospyros virginiana*, Oct. 10, 1926, *J. R. Weir* (PDS 66661).

North Carolina: Salem, on posts of garden fence, 1825, *Schweinitz*, TYPE (Pa).

South Carolina: North Augusta, *Berry Benson* (L 12313).

Georgia: Tallulah Falls, Sept. 19, 1901, *A. B. Seymour* (F).

Florida: De Funiak Springs, *G. C. Fisher* (L 12324).

Louisiana (?): on *Quercus macrocarpa*, *A. B. Langlois* (PDS).

Ohio: Akron, *G. D. Smith* (L 12310); Salem, on ash, *B. Leeper* (L 12311); Toledo, *W. R. Lowater* (L 35854), and TYPE of *D. fissa* (L 12382).

West Virginia: Pendleton Co., on *Fagus ferruginea*, Sept. 17,

1904, *A. H. Moore 2321* (F); Fairmont, *Rev. A. Boutlou* (L 12328); Radnor, on burned *Quercus alba*, Nov. 28, 1920, *C. L. Shear* (S).

Michigan: Croton, on dead white oak, Sept. 20, 1914, *C. D. LaRue* (Po 617A, L 12318); Mt. Pleasant, Dec. 1913, *A. E. Jenkins* (PDS).

Indiana: Sandusky, on dead *Quercus alba*, Aug. 17, 1912, *C. J. Humphrey* (L 12317); Scottsburg, on dead *Quercus alba*, *J. R. Weir 21070* (PDS).

Wisconsin: Green Bay, on dry *Fagus*, July 24, 1889, *J. W. Schuette* (PDS); Shawano, on healthy plum limbs, June 14, 1897, *W. S. Wood* (PDS).

Illinois: Evanston, Oct. 4, 1909, *L. H. Pennington* (L 12320).

Minnesota: Minneapolis, *Mary S. Whetstone* (L 12306, 12308); Rochester, *J. E. Greene* (L 12309).

Iowa (?): *T. H. MacBride* (Ia 1419).

Missouri: St. Louis Co., on dead trunk, April 6, 1919, *S. M. Zeller* (MBG 12326); Old Orchard, Oct. 1886, *Pammel* (MBG 66605); *T. H. MacBride* (Ia 1383); Dixon, on fire-killed *Acer rubrum*, July 1928, *Marion Child* (MBG); Lesterville, on charred *Quercus*, Nov. 1926, *L. O. Overholts* (MBG 63847).

North Dakota: Kulm, on *Fraxinus*, Dec. 14, 1913, *J. F. Brenckle, 2758* (PDS, St 678).

Kansas: Fort Riley, on oak poles, Oct. 1917, *J. F. Brenckle, 99* (F, L, PDS).

Texas: College Station, *L. W.* (L 10812).

Montana: Darby, on *Alnus tenuifolia*, July 1915, *J. R. Weir, 6298* (PDS).

Idaho: Priest River, on *Alnus tenuifolia*, Oct. 1915, *J. R. Weir, 2761* (PDS).

Washington: Chelan Lake, on *Alnus tenuifolia*, Sept. 1916, *J. R. Weir, 2759* (PDS).

Oregon: Corvallis, *S. M. Zeller* (MBG).

Mexico: (Ia 1353); Jalapa, *C. L. Smith* (Ia 1415).

Central America:

Honduras: *O. A. Reinking* (L 12316).

West Indies:

Cuba: Oriente, Guantanamo, on lianas, 1918, *B. Hioram, 12486* (PDS).

South America:

Brazil: Minas Geraes, 1877, *F. Noack* (St 267).

Europe:

France: Seine-et-Oise, *F. Sarrazin, 3946* (F).

Italy: Treviso, on dead trees, Sept. 1894 (F), on trees, Sept. 1872, *P. A. Saccardo* (St 18); L. Maggiore, autumn of 1865 (St 361); Vercelli, *Cesati* (St 600).

Germany: Berlin, on trees stumps, 1890–91, *Sydow, 3469* (St, F).

Austria: Eberbach, on *Fagus* trunks, *Fuckel, 2468,* in Fungi Rhenan. (F); on *Alnus,* Oct. 26, 1904, *von Höhnel, 4350* (F).

Hungary: Wieselburg, on *Betula alba,* Nov. 1882, *Linhart, 180* (F).

Rumania: Transylvania, Dec. 1872, *C. Barth, 1154* (F, PDS, St).

Russia: Majkop (?), on fallen logs, *N. Schestunow* (L 10882).

Philippine Islands: Manila, on fallen trunks, 1914, *A. Morgan, 12641* (PDS).

10. Daldinia simulans Child, sp. nov.

Pl. 26, fig. 2; pl. 28, fig. 2; pl. 30, fig. 3; pl. 33, fig. 4.

Stromata elongato-ellipsoidea vel subglobosa, substipitata vel breve-stipitata, plerumque solitaria, raro confluentia, sursum minute sulcata, "Snuff Brown," "Drab," vel "Verona Brown," 5–15 x 14–15 x 9–13 mm; stipitibus sterilibus zonatis, atris, fulgidis; ectostromatibus tenuibus; entostromatibus fibrosis, partim collabascentibus loculatisque, zonatis, zonis atris tenuibus, zonis pallidioribus "Pale Dull Gray," 4–5-plo latioribus; peritheciis monostichis, pyriformibus vel late ovoideis, 444–888 x 185–518 μ; sporidiis fuscis vel atro-fuscis, ellipsoideis vel subinaequilateraliter ellipsoideis, (9.6)–11.2–(14.4) x (4.8)–6.4–(8.) μ; conidiis solitariis vel verticillatis, hyalinis, elongato-ellipsoideis, 8–12.8 x 4.4 μ.

Stromata elongate-ellipsoidal or subglobose, substipitate or short-stipitate, usually single, occasionally confluent, minutely

transversely sulcate above, "Snuff Brown," "Drab," or "Verona Brown," 5–15 x 14–15 x 9–13 mm.; sterile stipe zonate, black and shining. Ectostroma thin. Entostroma fibrous and partially collapsing, somewhat loculate, zonate, the thinner zones thin and black, the lighter zones 4–5 times broader, "Pale Dull Gray." Perithecia monostichous, subdistant, pyriform to broadly ovoid, 444–888 x 185–518 μ, the walls 29.6–37 μ thick. Ascospores fuscous to deep fuscous, ellipsoid to subinequilaterally ellipsoid, (9.6)–11.2–(14.4) x (4.8)–6.4–(8) μ. Conidia solitary or in whorls, hyaline, elongate-ellipsoid, 8–12.8 x 4.4 μ.

On wood of deciduous trees. Ohio, Illinois, and Missouri.

This species is close to *D. vernicosa* but differs from it by the usually smaller ascocarps, which are brownish rather than purplish and in young material are somewhat transversely rugose. The stipe, also, is more conspicuously annulate from the internal concentric zones. Physiologically this species, previously known as *Daldinia X*, is also distinct, as has been reported by the writer.[33]

Specimens examined:

United States:

Ohio: Cincinnati, Sept. 22, 1920, *C. G. Lloyd* (L 11758).

Illinois: Evanston, Sept. 29, 1928, *H. Fox* (Po 229e).

Missouri: Valley Park, Sept. 1929, *D. H. Linder*, TYPE (Li, MBG); Dixon, Aug. 1929, *Marion Child* (MBG).

11. Daldinia albozonata Lloyd, Myc. Writings **5**: 822. *fig. 1374*. March, 1919; *ibid.* 25. *fig. 1456*. July, 1919 (char. emend.).

Pl. 27, fig. 3; pl. 31, fig. 3.

Stromata mutua pressione irregulariter turbinata, dense caespitosa, subito in stipites crassos attenuata, .5–2 x 1–2 x .5–3 cm.; ectostromatibus "Dark Vinaceous Drab," "Dusky Drab," deinde "Anthracene Purple" vel atris, numquam fulgidis; stipitibus manifesto zonatis, longitudinaliterque rugosis, nemorosis; entostromatibus contextis vel fibrosis, persistentibus, non collabascentibus, manifesto zonatis, zonis obscurioribus "Bone Brown," fibrosis, zonis pallidioribus "Tilleul White," 4–5 plo latioribus; peritheciis late claviformibus, ad bases attenuatis, non dense

[33] Child, M. Ann. Mo. Bot. Gard. **16**: 411–486. 1929.

aggregatis, in totis peripheris stromatum, 148–370 x 370–740 μ; ostiolis prominentibus; ascis non persistentibus; sporidiis dilute fuscis, cymbiformibus, (6.4)–8–(9.6) x (2.4)–3.2–(4.8) μ.

Stromata irregularly turbinate by mutual pressure, densely cespitose, substipitate, .5–2 x 1–2 x .5–3 cm. Ectostroma "Dark Vinaceous Drab" to "Dusky Drab," finally "Anthracene Purple" to dull black or bronze-black, never shining; the stipe conspicuously zonate and longitudinally rugose, woody. Entostroma pithy, fibrous, persistent, conspicuously zonate, the lighter zones "Tilleul White" and 4–5 times broader than the darker "Bone Brown" zones. Perithecia borne over the entire stroma, broadly claviform, long-tapering at the base, subdistant, 148–370 x 370–740 μ, the walls 37 μ thick; ostioles prominent. Ascospores navicular, light fuscous, (6.4)–8–(9.6) x (2.4)–3.2–(4.8) μ.

The material upon which Lloyd based the species was sent from the Cameroons in Africa. As he remarks, it does suggest *D. vernicosa* because of the white inner context, which is firm, and a dull rather than a shining ectostroma. According to Lloyd, the ascospores measure 4 x 8 μ, but the writer has found them to be somewhat more variable and, for the most part, narrower.

Specimens examined:

AFRICA:

French Equatorial Africa (Cameroons): *G. Zenker*, TYPE (L 12375).

Angola: *J. W. Gossweiler* (L 12395).

Uganda: Mevu (?), alt. 1900 m. (PDS); Magungo (?), alt. 1300 m., *Dr. O. Mattiook, Balbo* (PDS).

12. **Daldinia cuprea** Starbäck, Kongl. Svensk Vet.-Akad. Handl. III. **27**[9]: 5. *fig. 2.* 1901.

Daldinia granulosa Spegazzini, Anal. Mus. Nac. Buenos Aires III. **12**: 345. 1909.

Pl. 27, fig. 1; pl. 28, fig. 6; pl. 30, fig. 7; pl. 31, fig. 4.

Stromata narrowly clavate, solitary, the stipe differentiated from the fertile head, conspicuously annularly zoned and rugose, 1.2–1.7 x 1–1.5 x 5–6.6 cm. Ectostroma thin, at first "Seal Brown," "Sorghum Brown," becoming "Dark Vinaceous Brown," and

finally black and laccate. Entostroma conspicuously zonate, the lighter zones "Tilleul Buff," "Light Buff," "Cinnamon" to "Pinkish Buff," or "Mouse Gray," fibrous to pithy, collapsing and loculate, 3–4 times broader than the darker and more persistent "Bone Brown" zones. Perithecia confined to the head, monostichous, napiform, 740–888 x 444–518 μ; the wall 22.2–29.6 μ thick. Ostioles large, prominent, close together. Ascospores navicular, amber-colored, the ends acutely rounded, lighter-colored, and refractive, (8)–9.6–(11.2) x 4.8 μ.

On wood of deciduous trees. Paraguay and Argentina.

This species is characterized by the presence of papillate ostioles and by the fact that the stipe, conspicuously annulate exteriorly, is sharply separated from the perithecium-bearing upper portion of the stroma.

A comparison of the types of *D. cuprea* and *D. granulosa* shows conclusively that the two species are identical.

Specimens examined:

South America:

Paraguay: Paraguari, Cerro Negro, Aug. 8, 1893, *G. O. Malme*, TYPE (St 6).

Argentina: Rio Pescado, Jujuy, March 1905, *Spegazzini*, TYPE of *D. granulosa* (A).

Island of Ta (probably in Argentina): April 1, 1902, *R. E. Fries* (St 373), and April 10, 1902, *R. E. Fries* (St 425).

Locality unknown: March 22, 1902, *R. E. Fries* (St 337).

13. **Daldinia clavata** Hennings, Hedwigia **41**: 14. 1902.

Daldinia vernicosa var. *microspora* Starbäck, Kongl. Svensk Vet.-Akad. Handl. III. **27**[9]: 6. 1901.

Daldinia barbata Rick, Broteria **5**: 50. 1906.

Daldinia argentinensis Spegazzini, Anal. Mus. Nac. Buenos Aires III. **1**: 68. 1902.

Daldinia argentinensis Speg. f. *sessilis* of authors in part, Anal. Mus. Nac. Buenos Aires III. **12**: 345. 1909.

Pl. 27, fig. 2; pl. 30, fig. 6; pl. 33, fig. 5.

Stromata cylindrical to broadly clavate, sessile or contracted below into a short somewhat rugose stipe, single, rarely confluent,

laterally compressed, smooth or finely rugose, 1–6 x .9–4.5 x 1–5 cm. Ectostroma thin, brittle, at first "Hay's Brown" or "Dark Vinaceous Brown," finally dull to shiny black and laccate. Entostroma persistent, definitely zonate, the lighter zones "Tilleul Buff," "Hair Brown," "Drab Gray," or "Vinaceous Buff," fibrous to pithy and 4–5 times broader than the darker and more compact "Bone Brown" zones. Perithecia monostichous or polystichous, claviform, borne over almost the entire stroma, 740–1086 x 236–370 μ; the walls 22.2–29.6 μ thick. Ostioles distant, obsolete to punctiform. Ascospores amber-colored, navicular to subinequilaterally ellipsoid, ends acutely rounded, lighter colored, and refractive, (8)–9.6–(12.8) x (3.2)–4.8–(6.4) μ.

On wood of deciduous trees. Mexico, Guatemala, Brazil, and Argentina.

The obsolete ostioles and the conspicuously collapsing tissue of the entostroma separate this species from *D. cuprea.* It is further differentiated by the fact that the fertile portion of the fruiting body is not clearly distinguishable from the short stipe.

Specimens examined:

MEXICO: Vera Cruz, on trees, Dec. 1907, *C. A. Purpus* (L 12390); Mexico City, *S. Bonansea* (L 12391).

CENTRAL AMERICA:

Guatemala: *T. J. Collins* (L 12380); *Silas L. Schumo* (L 12397).

SOUTH AMERICA:

Brazil: Matto Grosso, Guia, May 13, 1894, *G. O. Malme,* authentic material of *D. vernicosa* var. *microspora* (St); Rio Grande do Sul, Lagedo, *Rick* (L 12304, 12393), 1921, *Rick* (PDS 19805); Rio Grande do Sul, 1904, *Theissen* (F) probably authentic; St. Catharina Island, Blumenau, 1892, *A. Möller,* TYPE (B).

Argentina: Missiones, Puerto Pampa, Jan. 1901, *E. Kermes,* TYPE of *D. argentinensis* (A); Jujuy, Rio Pescado, on dead trees, March 1905, *Spegazzini,* TYPE of *D. argentinensis* f. *sessilis* (2) (A).[34]

[34] The number in the bracket was used by the author in order to separate Spegazzini's mixed collection, which bore no number. The original packet contained a mixed collection and the author has separated the specimens accordingly: No. 1, *D. Eschscholzii;* No. 2, *D. clavata;* No. 3, *Hypoxylon* sp.

DOUBTFUL OR EXCLUDED SPECIES

Daldinia angolensis (Welw. & Curr.) Sacc. Syll. Fung. **1**: 394. 1882.

Hypoxylon angolense Welw. & Curr. Trans. Linn. Soc. Bot. **26**: 282. 1868.

The writer has been unable to examine the type material of this species, although she has studied specimens in the Lloyd Herbarium that pass under this name. In none of these, zonation is evident, hence the species should probably be placed in *Hypoxylon* in accordance with Welwitsch and Currey.[35] However, since the species has been placed in *Rhopalopsis, Kretzschmaria,* and *Camillea,* the writer feels that it is inadvisable to make a definite disposition of the species.

Daldinia aspera Massee, Kew Bull. Misc. Inf. **1898**: 134. 1898. There is no evidence of definite zonation in the type material of this species. It probably should be considered a large tropical species of *Hypoxylon,* either close to or synonymous with *H. cerebrinum* Fée.

Daldinia asphalatum (Link) Sacc. Syll. Fung. **1**: 394. 1882.

Sphaeria asphalatum Link et Fries, Linnaea **5**: 540. 1830.

The entostroma of the type of this species is homogeneous. The writer has found this species under *D. Eschscholzii, D. occidentale,* and *D. Gollani.* It is probably a species of *Hypoxylon.*

Daldinia durissima (Schw.) Sacc. Syll. Fung. **1**: 394. 1882.

Sphaeria durissima Schw. Syn. Fung. Car. Suppl. 32. 1822.

This species is doubtfully *D. concentrica.* A photograph of the type was available for study (pl. 30, fig. 1), as was also a preparation of the ascospores. From a photograph it was impossible to see any evidence of zonation in the entostroma. The spores, however, are of the same size as those of *D. concentrica.* According to Cooke,[36] this is a synonym of *Hypoxylon marginatum.*

[35] Welwitsch, F. & F. Currey. Trans. Linn. Soc. Bot. **26**: 282. 1868.
[36] Cooke, M. C. Grevillea **11**: 121–140. 1883.

Daldinia exsurgens (Mont.) Rehm, Ann. Myc. **7**: 4. 1909.

Hypoxylon exsurgens Mont.-Guy. Syll. Gen. Spec. Crypt. 213. 1856.

This species was placed in *Daldinia* because of the very faint zones present in the entostroma. The type material, although showing the faint zones, appears to be referable to *Hypoxylon* near *H. herculeum.*

Daldinia Feei Sacc. Syll. Fung. **1**: 395. 1882.

This species was originally described by Fée[37] in *Sphaeria,* but from that genus it was transferred to *Daldinia* by Saccardo,[38] who, however, renamed it, since the name *D. vernicosa* was preëmpted. Later, Saccardo[39] with good reason transferred the species to *Xylaria* where it properly belongs. *D. Feei* is therefore synonymous with *Xylaria vernicosa* (Fée) Saccardo.

Daldinia placentiformis (B. & C.) Theissen, Ann. Myc. **7**: 4–5. 1909.

Hypoxylon (*Glebosae*) *placentiforme* Berk. & Curt. Fungi Cubensis, 383. 1867.

The homogeneous context of the authentic material seen by the writer excludes this species from *Daldinia.*

Daldinia stratosa Sacc. Syll. Fung. **22**: 327. 1913.

Hypoxylon stratosum Sacc. Syll. Fung. **9**: 544. 1891. Ita nuncupandum a *D. Eschscholzii* (Ehrenbg.) Rehm, Sacc. Syll. Fung. **17**: 617. 1905.

The writer has seen no specimen of this species. Saccardo has called it a *D. Eschscholzii.*

Daldinia Thouarsiana (Lév.) Sacc. Syll. Fung. **1**: 395. 1882.

Sphaeria Thouarsiana Lév. Ann. Sci. Nat. Bot. III. **5**: 258. 1846.

The context of the type material is homogeneous. The species should be placed in *Hypoxylon.* It has been variously considered as either *H. Thouarsianum* or *H. malleolus.*

[37] Fée, A. L. A. Nouv. Mém. Soc. Sci. Agr. et Arts du Dept. Bas Rhin 2^1: 143–146. *pl. 12, fig. 2.* 1834.

[38] Saccardo, P. A. Syll. Fung. **1**: 395. 1882.

[39] *Ibid.* **9**: 530. 1891.

Daldinia Warburgii Hennings, Fungi Warburg. Hedwigia **32**: 225. 1893.

The type material shows a homogeneous context. The ascospores are a very dark brown color and are extremely long and narrow. The material examined obviously belongs in *Hypoxylon*.

Explanation of Plate

PLATE 26

All photomicrographs were taken at a magnification of approximately × 815.

Fig. 1. *Daldinia vernicosa*, from material collected in Missouri (Li).

Fig. 2. *Daldinia simulans*, from type material.

Figs. 3–4. *Daldinia loculata.*

Fig. 5. *Daldinia Eschscholzii*, from material collected in the Bahamas, by A. D. Machado (L 12385).

Figs. 6–7. *Daldinia caldariorum*, from type material.

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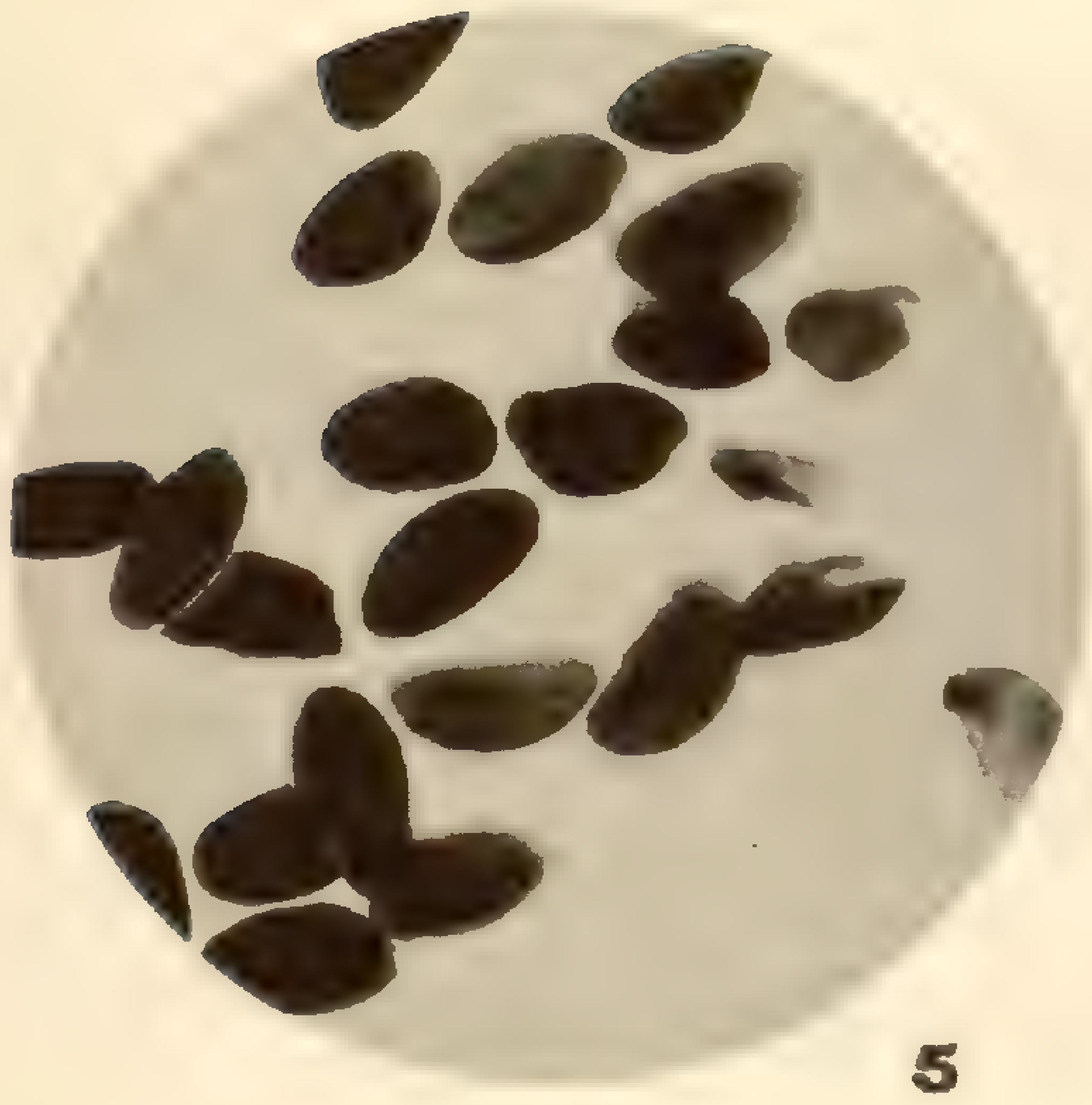

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7

CHILD—THE GENUS DALDINIA

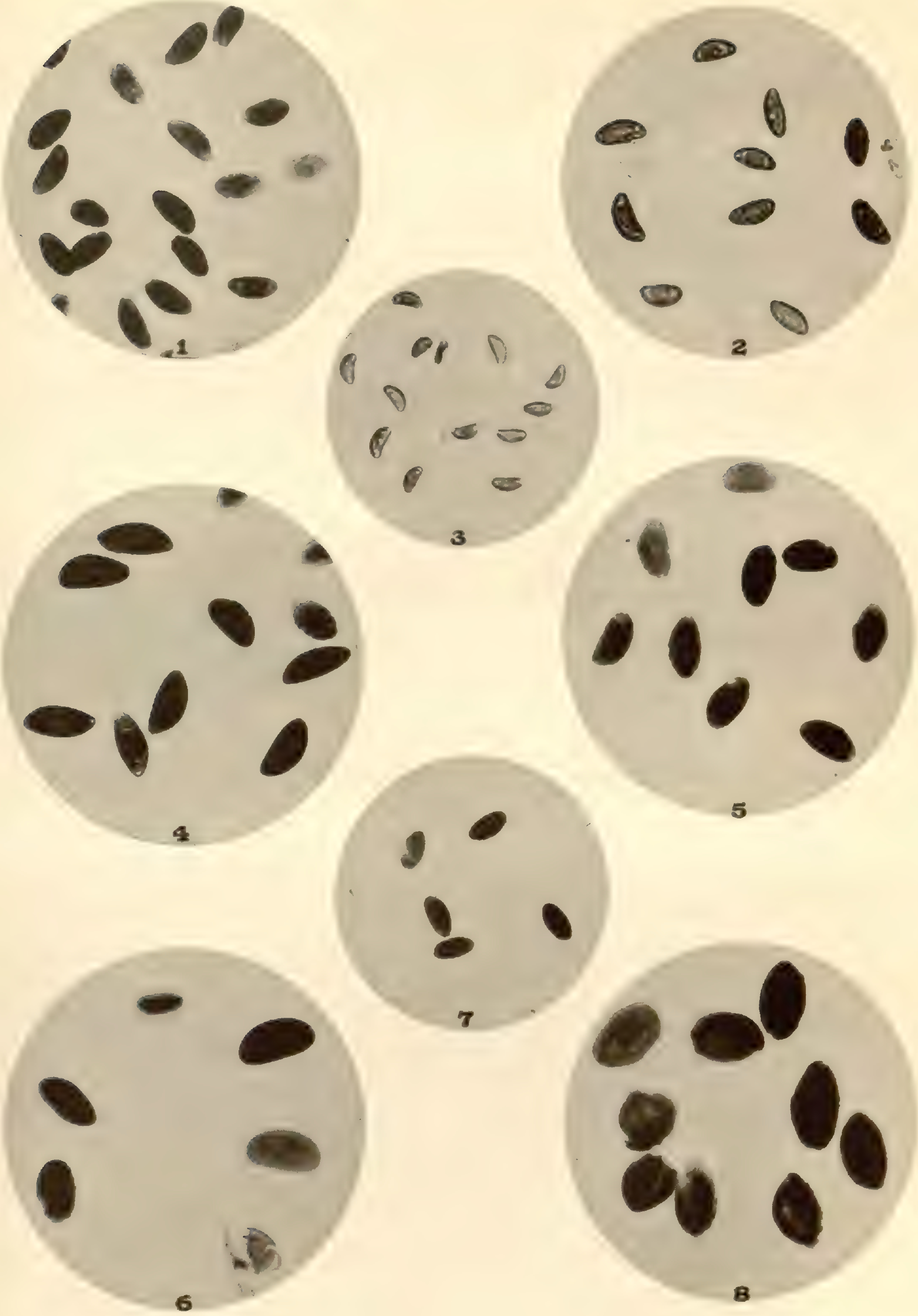
COCKAYNE, BOSTON

Explanation of Plate

PLATE 27

All photomicrographs were taken at a magnification of approximately × 815.

Fig. 1. *Daldinia cuprea*, from type material.
Fig. 2. *Daldinia clavata.*
Fig. 3. *Daldinia albozonata*, from type material.
Fig. 4. *Daldinia concentrica*, from material collected in Missouri by P. Spaulding.
Fig. 5. *Daldinia Eschscholzii.*
Fig. 6. *Daldinia occidentale*, from type material.
Fig. 7. *Daldinia Gollani*, from type material.
Fig. 8. *Daldinia grande*, from type material.



CHILD—THE GENUS DALDINIA

Explanation of Plate

PLATE 28

The photomicrographs were all taken at a magnification of × 13.

Fig. 1. *Daldinia vernicosa.* Note the shining surface and the well-spaced ostioles.

Fig. 2. *Daldinia simulans.* In this species, especially in material that is not quite mature, the surface is characteristically wrinkled, and the ostioles are inconspicuous.

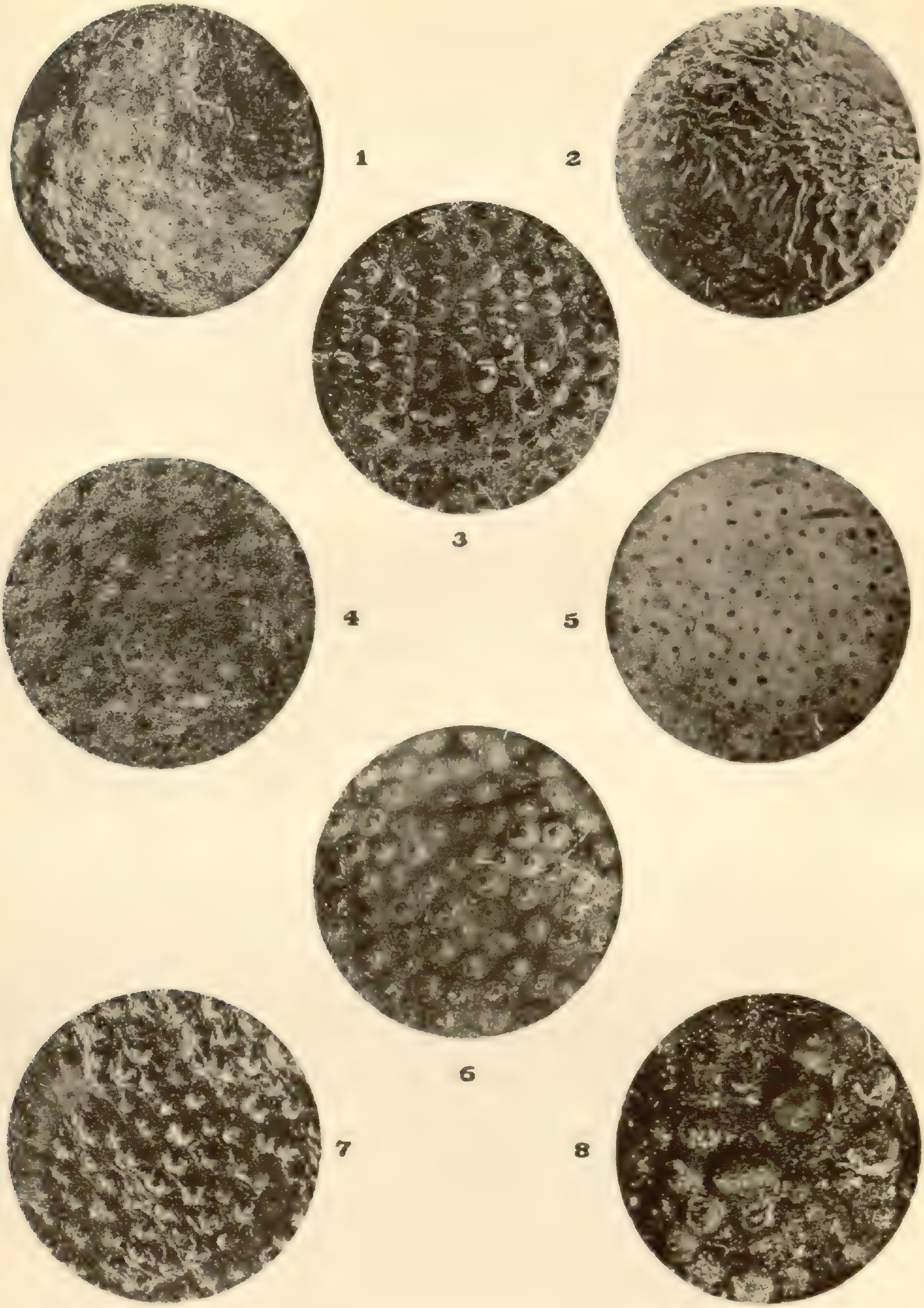
Fig. 3. *Daldinia occidentale.* The ectostroma is papillate around the ostioles, but the mouths of the ostioles are not pronounced.

Fig. 4. *Daldinia concentrica.* In this specimen the ostioles are not pronounced.

Fig. 5. *Daldinia Eschscholzii.* The ostioles in material that has not been rubbed or weathered are conspicuous as black dots.

Fig. 6. *Daldinia cuprea.* The ostioles are prominent and extend beyond the papillate ectostroma.

Figs. 7–8. *Daldinia grande.* The *Rosellinia*-like ostioles shown in fig. 8 are from the same fruiting body as are the smaller ones shown in fig. 7.



CHILD—THE GENUS DALDINIA

Explanation of Plate

PLATE 29

The scale accompanying each figure equals 1 centimeter.

Fig. 1. *Daldinia concentrica,* from Jugo-Slavia (St).

Fig. 2. *Daldinia concentrica,* from Germany (St). Note the rather prominent ostioles.

Fig. 3. *Daldinia Eschscholzii,* from Burma (St 1120).

Fig. 4. *Daldinia concentrica.*

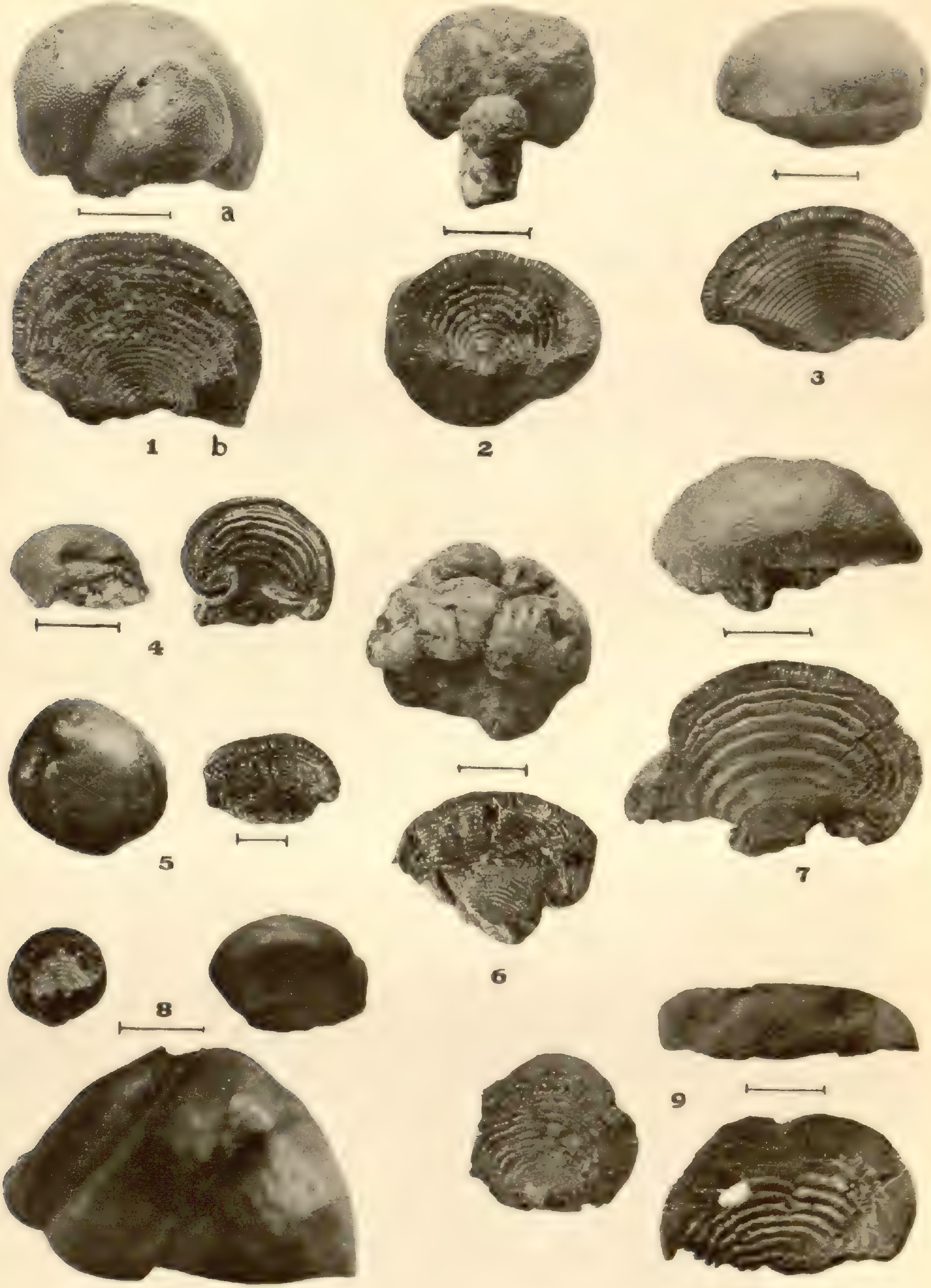
Fig. 5. *Daldinia Eschscholzii,* from the Philippine Islands, collected by M. Ramos at Antipalo, Luzon. Distributed from the Herbarium of the Bureau of Science at Manila, as *Daldinia concentrica* var. *microspora* (Starb.) Theiss.

Fig. 6. *Daldinia Eschscholzii* (Forestry Bureau no. 19201 of the Bureau of Science at Manila). This species with the convoluted stroma was distributed as *Daldinia concentrica.*

Fig. 7. *Daldinia concentrica* (Norfolk, England, *C. B. Plowright, 69* (St)).

Fig. 8. *Daldinia Eschscholzii,* from Mozambique.

Fig. 9. *Daldinia concentrica,* from Germany.



CHILD—THE GENUS DALDINIA

Explanation of Plate

PLATE 30

The scale accompanying each figure equals 1 centimeter.

Fig. 1. *Daldinia concentrica.* The type of *D. durissima* (Schw.) Sacc. The ostioles of the somewhat weathered material are rather prominent for this species.

Fig. 2. *Daldinia vernicosa,* from Canton, Massachusetts.

Fig. 3. *Daldinia simulans,* from Evanston, Illinois.

Fig. 4. *Daldinia loculata,* from Preston, Ohio. Note the definite, cylindrical stipe.

Fig. 5. *Daldinia vernicosa.* Type specimen in the Schweinitz Herbarium.

Fig. 6. *Daldinia clavata,* from Jujuy, Argentina, the type of *D. argentinensis* Speg.

Fig. 7. *Daldinia cuprea,* from Paraguay. Type material. The prominent ostioles and the less conspicuously zonate and loculate entostroma aid in separating this from the preceding species.

Fig. 8. *Daldinia grande.* Type material. Note the variation in the size and prominence of the ostioles.

CHILD—THE GENUS DALDINIA

Explanation of Plate

PLATE 31

The drawings of the perithecia were all made with the aid of the camera lucida and are all drawn to the same magnification.

Fig. 1. *Daldinia Eschscholzii,* drawn from a thick section and hence does not show the thickness of the ectostroma.

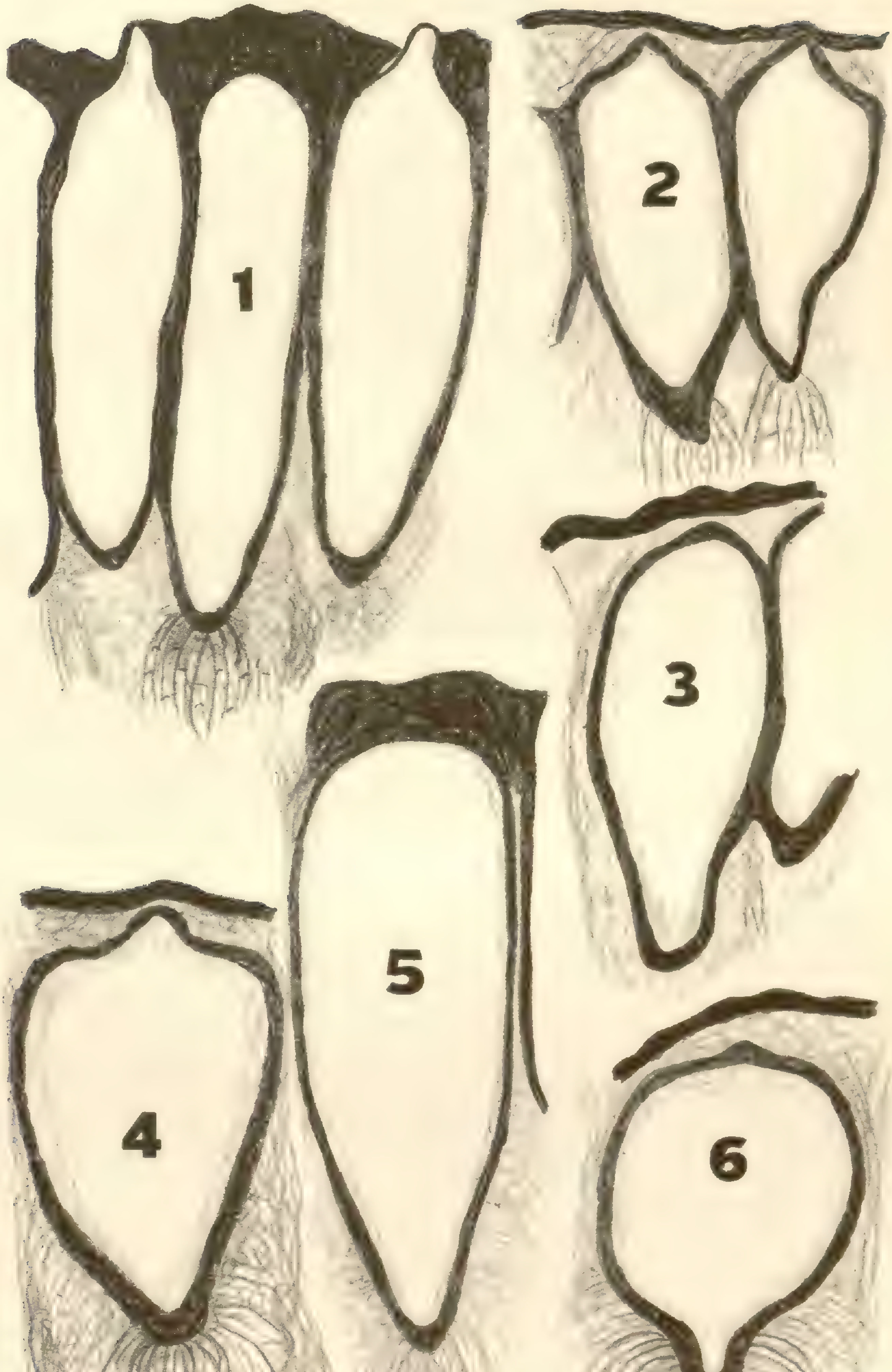
Fig. 2. *Daldinia caldariorum,* from type material.

Fig. 3. *Daldinia albozonata,* from type material.

Fig. 4. *Daldinia cuprea,* from specimen collected in Argentina (?) (St).

Fig. 5. *Daldinia Bakerii,* from type material.

Fig. 6. *Daldinia Gollani,* from type material.



CHILD—THE GENUS DALDINIA

Explanation of Plate

PLATE 32

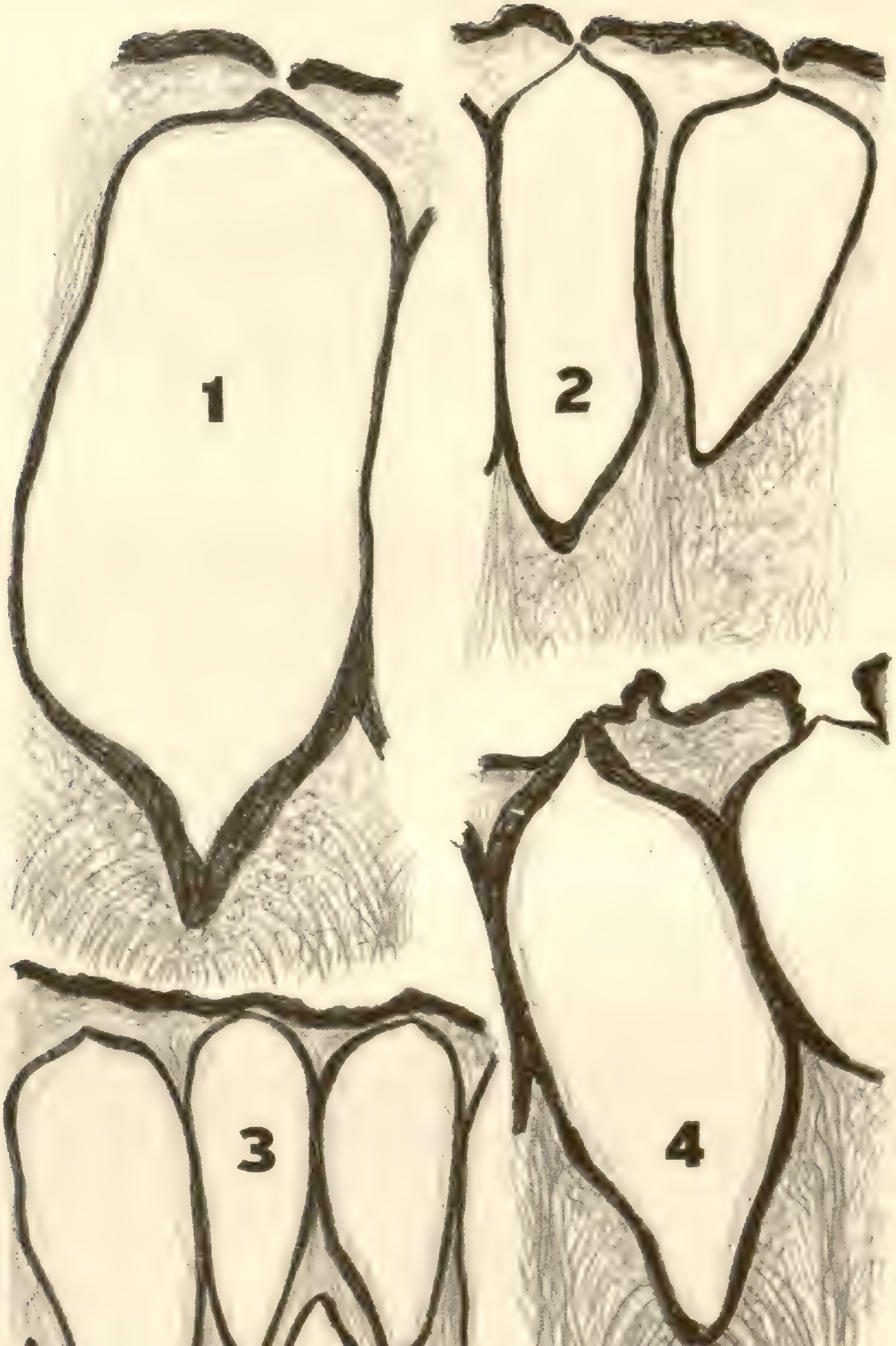
The drawings of the perithecia were all made with the aid of the camera lucida and are drawn to the same magnification.

Fig. 1. *Daldinia loculata,* from material collected in Iowa (Ia 1352).

Fig. 2. *Daldinia loculata,* from material collected in Ohio (Ia). Note the difference within the species of perithecial size and shape.

Fig. 3. *Daldinia grande,* from type material. In this species the perithecia are usually polystichous.

Fig. 4. *Daldinia occidentale,* from material collected by A. S. Rhoads, at Metaline Falls, Washington (PDS). Note that the ostiole penetrates through the ectostroma.



CHILD—THE GENUS DALDINIA

Explanation of Plate

PLATE 33

The drawings of the perithecia were all made by the aid of a camera lucida and are all drawn to the same magnification.

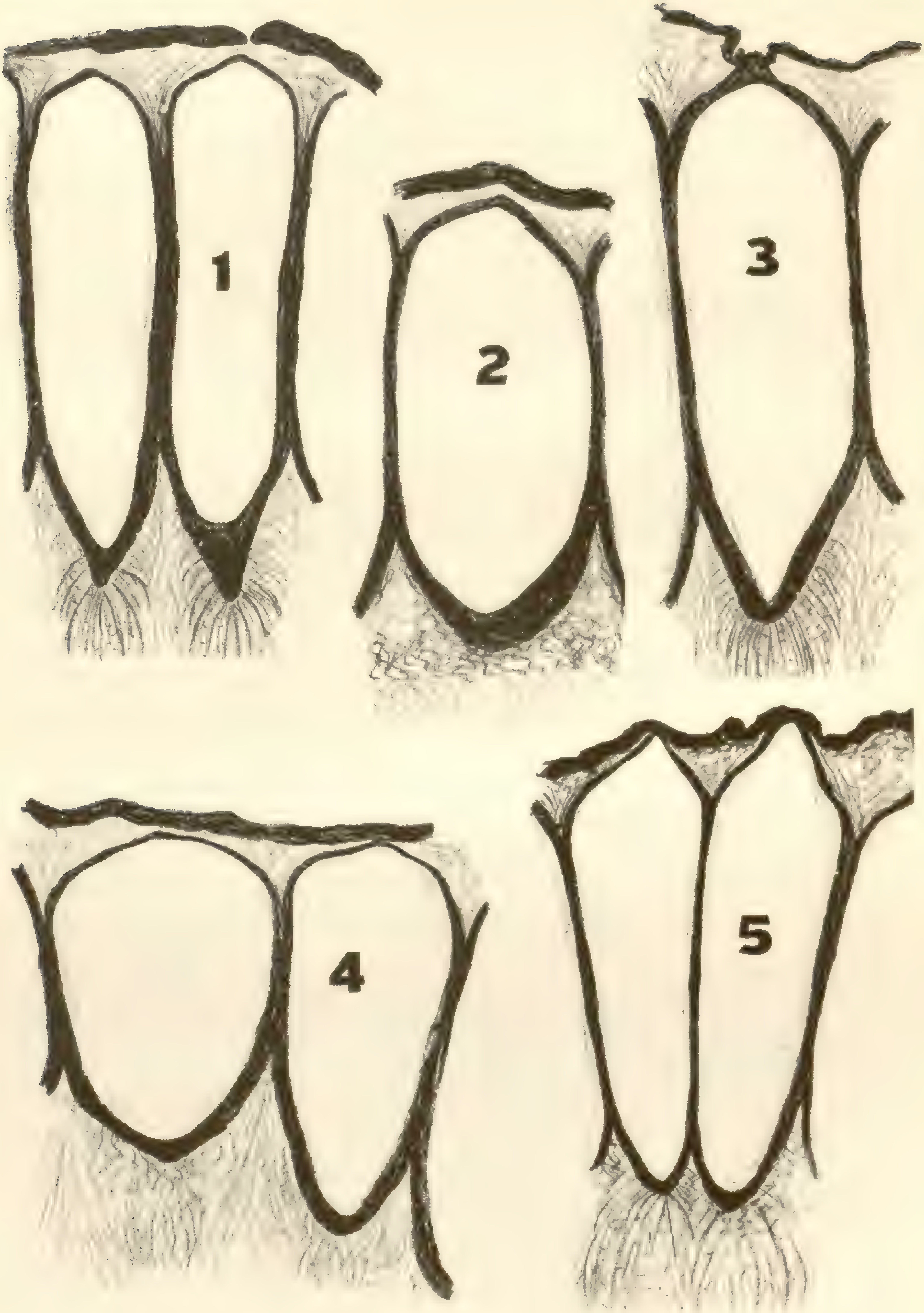
Fig. 1. *Daldinia concentrica*, from material collected in Missouri by Marion Child.

Fig. 2. *Daldinia vernicosa*, from material collected at Fort Riley, Kansas, by Brenckle.

Fig. 3. *Daldinia Eschscholzii*, from material collected in Argentina.

Fig. 4. *Daldinia simulans*, from type material.

Fig. 5. *Daldinia clavata*, from material collected at Matto Grosso, Brazil, by G. O. Malme (St).



CHILD—THE GENUS DALDINIA

STUDIES IN THE UMBELLIFERAE. IV[1]

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A New Species of Cogswellia

Cogswellia minima,[2] n. sp.

Plants acaulescent, 1–3.5 cm. high, glabrous or scabrous-puberulent; leaves narrowly oblong in general outline, excluding the petiole, 0.5–2.5 cm. long, about 1 cm. broad, simply pinnate with 4–6 pairs of acute, distinct, entire leaflets, 2–10 mm. long, 1–1.5 mm. broad, petiole 1–6 mm. long; peduncles equalling or slightly exceeding the leaves, 1–3.5 cm. long, umbels few-rayed, rays unequal, 3–10 mm. long, pedicels 1–2 mm. long, involucre usually absent, rarely one bract present, involucel subdimidiate, of several more or less distinct, narrow, acute, foliaceous, somewhat scarious-margined bracts, shorter than the yellow flowers; fruit glabrous, oblong in general outline, 4–7 mm. long, 3–4 mm. broad, lateral wings well-developed, dorsal surface prominently ribbed, oil tubes more or less obsolete, strengthening cells present at the base of the wings.

Type specimen: *Mathias 670,* near the hotel, dry slopes bordering Bryce Canyon, Utah, 8600 ft. alt., 18 July 1929 (type in the Missouri Botanical Garden Herbarium).

Distribution: known only from the type locality and the Panguitch Plateau above Cedar Breaks, southwestern Utah.

[1] Issued November 15, 1932.

[2] **Cogswellia minima** Mathias, nov. sp.—Planta acaulis, 1–3.5 cm. alta, glabra vel scabro-puberula; foliis anguste oblongis, petiolis excludentibus, 0.5–2.5 cm. longis, circiter 1 cm. latis, simpliciter pinnatis, foliolis oppositis, 8–12, acutis, distinctis, integris, 2–10 mm. longis, 1–1.5 mm. latis; petiolis 1–6 mm. longis; pedunculis foliis aequalibus vel longioribus, 1–3.5 cm. longis, umbellis pauciradiatis, radiis inaequalibus, 3–10 mm. longis, pedicellis 1–2 mm. longis; involucro plerumque nullo; involucellis subdimidiatis, bracteis pluribus, plus minusve distinctis, angustis, acutis, foliaceis, marginibus subscariosis; floribus flavis brevioribus; fructibus glabris, oblongis, 4–7 mm. longis, 3–4 mm. latis, alis lateralibus conspicuis, jugis dorsalibus prominentibus, vittis plus minusve obsoletis, cellis firmantibus ad basem alarum.—*Mathias 670,* near the hotel, dry slopes bordering Bryce Canyon, Utah, 8600 ft. alt., 18 July, 1929 (type in the Missouri Botanical Garden Herbarium).

Specimens examined:

UTAH: Panguitch, 18 July 1920, *M. E. Jones* (P[3] 117944); Cedar Breaks, 17 July 1922, *M. E. Jones* (P 117313); near the hotel, dry slopes bordering Bryce Canyon, 8600 ft. alt., 18 July 1929, *Mathias 670* (M TYPE); on the edge of the Breaks, between the hotel and the camp ground, Cedar Breaks, near Cedar City, Iron Co., about 10,000 ft. alt., 19 July 1929, *Mathias 734* (M).

This species is characterized by its dwarf size, the short leaflets, and the short pedicels. It is most closely related to those species of *Cogswellia* referred by Coulter and Rose to the genus *Cynomarathrum* but may be readily distinguished from these species, especially from *Cogswellia Nuttallii* (Gray) Jones and its varieties from northern Nevada and Utah, by the three characters mentioned above and by its distribution in southwestern Utah.

[3] P = Herbarium of Pomona College; M = Missouri Botanical Garden Herbarium.

Explanation of Plate

PLATE 34

Cogswellia minima Mathias. From the type specimen, *Mathias 670*, in the Missouri Botanical Garden Herbarium.

MATHIAS—A NEW SPECIES OF COGSWELLIA

AN APPARATUS FOR THE DETERMINATION OF CARBON DIOXIDE PRODUCTION IN PHYSIOLOGICAL PLANT STUDIES

F. LYLE WYND

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From time to time, physiologists have proposed various methods for determining the amount of carbon dioxide evolved in physiological plant studies. These methods vary greatly in the apparatus used, conditions to which they are applicable, and degree of accuracy obtainable.

In the course of investigating the respiratory rate of plants in water culture, a large number of the published methods and apparatus was tested. It was found that liquid absorbents gave incomplete absorption unless the apparatus allowed the bubble to be broken at least three times during its passage through the liquid. In order to accomplish this, it was necessary to use an amount of absorbent which rendered the titration of small differences inaccurate, or to use special units of absorptive apparatus from which the absorbent could only inconveniently be completely removed for each titration.

In view of the inconvenience of using liquid absorbents the present apparatus was designed and it has proved so satisfactory that it was thought to be worthy of being brought to the attention of other workers. The general plan is an adaptation of the widely used method for determining carbon by combustion. The thorough absorption of carbon dioxide has been amply verified by many analysts.

The bell jar *H* is of any convenient size and rests on the glass plate *I*, the contact with which is sealed air tight with vaseline. Air enters the chamber through the large test-tube *D* (32 x 200 mm.) which is filled with soda lime or Ascarite, and is withdrawn through the larger test-tube *J* (38 x 300 mm.) which contains concentrated sulphuric acid. The Folin ammonia tube *K* is especially efficient in breaking up the air bubbles, insuring a more complete drying of the air stream. Tube *L* is of small size and contains phosphorous pentoxide. The absorption bulb

found most convenient was the Fleming or Fleming-Martin type and is designated *P*. The lower chamber contains Ascarite, and the upper, phosphorous pentoxide. The small test-tube *R* also contains phosphorous pentoxide. The air passes out through the suction line *E*. Tower *B* contains calcium chloride, and the jar *A* serves as a safety chamber to prevent water from entering the apparatus through the water pump which attaches to it. The

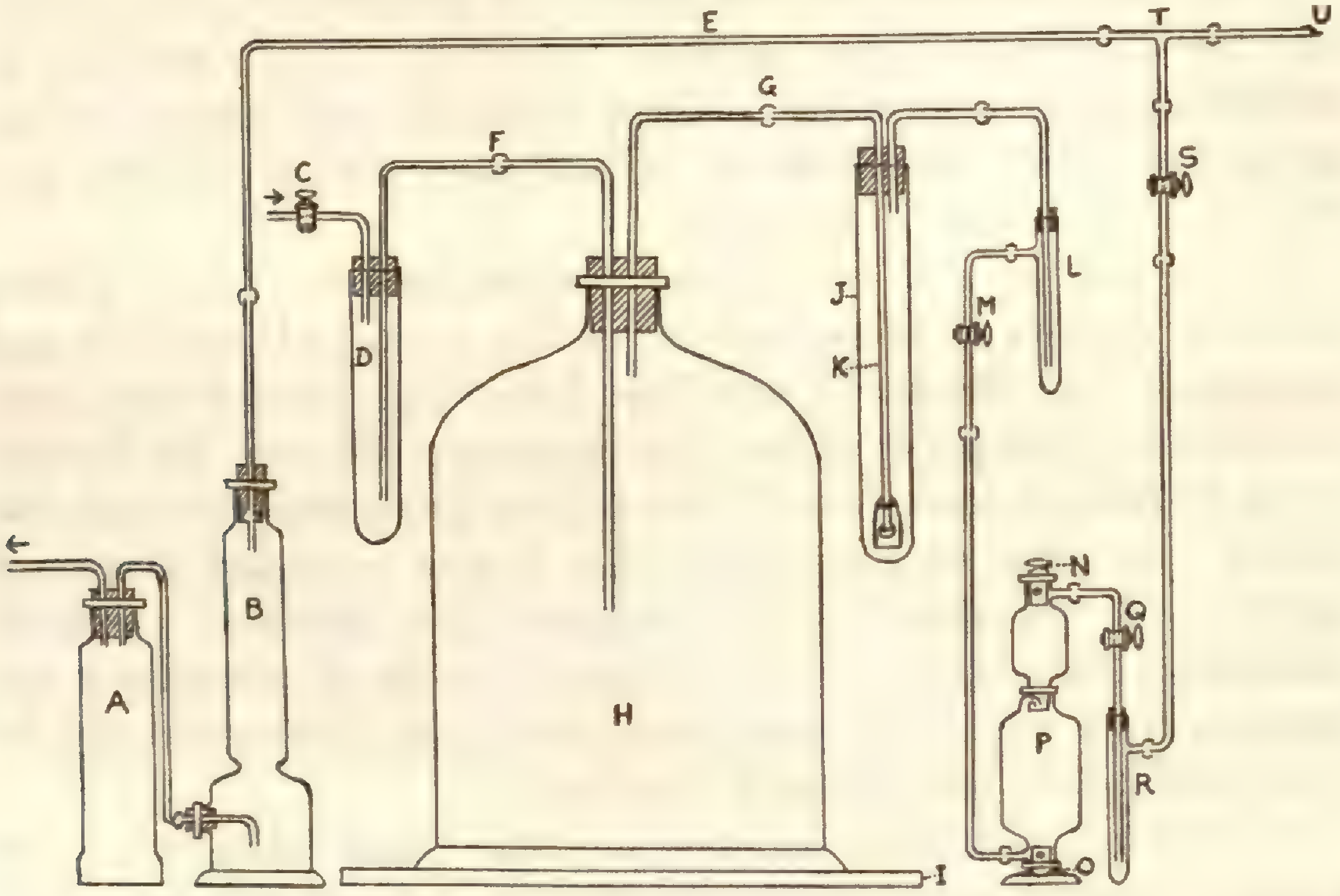

Figure 1

T-tube, *T*, allows several similar units to be operated simultaneously on the same suction line. The tubes *D*, *J*, *L*, and *R* are held in position by clamps.

In carrying out the determination, the rubber tube-connections *F* and *G* are disconnected, which enables the object of study to be placed beneath the bell jar. Stopcock *S* is then closed, and the suction turned on. By slowly opening *S* and counting the bubbles passing through the sulphuric acid tube *J*, the rate of flow may be controlled. The stopcock *S* is used to control the rate of flow rather than *M* or *Q*, because it can be adjusted and not altered. Stopcock *C* is closed when the apparatus is not in use.

Before disconnecting the Fleming bulb for weighing, stopcocks *M* and *Q* are closed to protect the phosphorous pentoxide in tubes *L* and *R* from contact with the atmosphere. The Fleming bulb is itself sealed by turning the top *N* and the base *O*. It is then disconnected and weighed on the analytical balance.

Owing to the impossibility of controlling accurately the temperature of the respiration chamber, for comparative results several units must be run simultaneously. Five units have been found to work very satisfactorily, attached to a single suction line.

The use of Ascarite as the carbon-dioxide absorbent is to be preferred over soda-lime, since its change in color as the carbon dioxide is absorbed indicates when renewal is necessary. A large number of determinations may be made with a single charge.

The drying agent must be more efficient than concentrated sulphuric acid and must be inserted in both sides of the Fleming bulb to establish proper equilibrium. Either phosphorous pentoxide or "Hydralo" (Al_2O_3) is satisfactory. In any case, a plug of glass wool should be inserted above it to prevent the air current from carrying away dust-like particles.

The accuracy of the determination is limited by the amount of carbon dioxide in the apparatus at the beginning and by the sensitivity of the balance used in weighing. The filled Fleming tube weighs about 150 grams, but this weight allows a balance sensitivity sufficiently great for most experiments.

A greater degree of accuracy may be obtained in weighing the Fleming bulb if it is allowed to stand on the balance twenty minutes, and the base opened and quickly closed before its weight is determined. A similar but unfilled bulb on the pan with the weights reduces the error involved by the presence of different amounts of moisture adsorbed on the surface at different times of the day.

The above-described apparatus is particularly adapted for measuring the carbon dioxide output of fruits, soils, and plants in water culture. In the latter case, the nutrient solution should be renewed just before the determination is made in order to reduce the possibility of introducing an error by the activity of micro-organisms.

A NEW SPECIES OF PARMELIA FROM TEXAS[1]

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Among the interesting lichens collected by Mr. Julian A. Steyermark and the writer in the mountains of western Texas was one *Parmelia* which appears to be unique. This is now described as:—

Parmelia incorrupta J. A. Moore, sp. nov.

Thallus 4–7 cm. latus, profunde lobato-incisus, lobi lati irregulariter undulato-crenulati non ciliati. Thallus juventate laevigatus vel maturitate reticulati-rugosus, punctis albis, sorediis et isidiis destitutus. Color flavulo-viridis glaucescens, subtus centrum nigrum asperum paucis rhizinis concoloribus, lobi juventate laevigatae fulvi nudi.

Cortex superior 20 μ altus, pseudoparenchymaticus, parte exteriore dilute fuscescens, ceterum hyalinus. Medulla alba, 100–125 μ alta, hyphae adspersa. Gonidia diam. 8 μ. Cortex inferior pachydermaticus fusconigrescens, 15 μ altus.

Apothecia numerosa, sessilia, rotunda vel angulosa, diam. 2–10 mm., margine eroso non ciliato. Gonidia sub excipulo et infra hymenio. Excipulum decolor, 70 μ altum, hypothecium 100 μ altum. Discus concavus badius laevigatus.

Hymenium superne fuscescens, subtus decolor, 60–75 μ altum. Paraphyses graciles, apices incrassata, libera. Asci ovati-clavati, octospori, 36 μ longi, 18 μ crassi. Sporae biserialiter dispositae, ellipsoideae, 12 μ longae.

Conceptacula pycnidiorum numerosa immersa, subglobosa, diam. 180 μ.

React. Omnes partes non mutantur. KOH –, CaCl –; KOH(CaCl) –.

TYPE COLLECTION: On bark of *Pinus flexilis* James, ridge above McKittrick Canyon, Guadalupe Mountains, Culberson Co., Texas. July 17, 1931. *J. A. Moore & J. A. Steyermark 3490*. TYPE in Herbarium at the Missouri Botanical Garden.

[1] Issued November 15, 1932.

Additional material seen:

Texas: on oak bark, Boot Spring, Chisos Mountains, Brewster Co., *J. A. Moore & J. A. Steyermark 3220* (MBG[1]); Ft. Bliss, *Mrs. Jos. Clemens 11358* (MBG).

Mexico: Mexico, *E. Palmer 1878* (MBG); oak trees, Orizaba, alt. 10,000 ft., *J. G. Smith 34* (MBG).

This new species belongs in the subgenus *Euparmelia*, section *Amphigymnia*, group *Subflavescentes*. It is most closely related to *Parmelia caperata* (L.) Ach., from which it differs in having a larger thallus, the upper surface being white punctate. The new species shows no color reactions with KOH and CaCl even after the reagents have been applied for several hours; while the thallus of *P. caperata* quickly responds to KOH by turning yellow, with CaCl no reaction, but with both reagents the thallus quickly becomes yellow below.

With the evident lack of chemical reaction of the new species in mind, the specific epithet *incorrupta* was chosen.

[1] MBG = Missouri Botanical Garden Herbarium.

SOME EFFECTS OF RADIATIONS FROM A MERCURY VAPOR ARC IN QUARTZ UPON ENZYMES[1]

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I. Review of Previous Experimentation

Numerous experiments have been performed with the object of determining the effects of radiations from mercury and carbon arcs and from the sun upon enzymes *in vitro*. The results have usually shown agreement, in one feature at least—that light sources which emit ultra-violet rays induce partial or complete inactivation of the irradiated enzyme solutions, depending upon the intensity or irradiation and the duration of exposure. In most of these experiments standardization of certain physical conditions of the procedures has been neglected, with the consequence that certain results have been at variance. The two features which have been most neglected are these: (1) Quantitative measurements of the energy emission of the light sources; (2) The determination of comparative effects of different portions of the spectrum upon the enzymes in question. In most of the published works, energy measurements have been omitted completely, so that it is impossible to review various experiments upon a comparative basis. Moreover, the destructive effects of the radiations have been assigned almost exclusively to the ultra-violet portion of the spectrum, with complete disregard for possible effects of other wave-lengths. It has been fairly well established that the visible rays exert little or no effect, but the influence of infra-red radiations which form a large percentage of the energy emission of arcs has been overlooked. Some of the more recent experimenters have irradiated enzyme solutions in quartz vessels immersed in water baths, but they have made no

[1] An investigation carried out at the Missouri Botanical Garden in the Graduate Laboratory of the Henry Shaw School of Botany of Washington University, and submitted as a thesis in partial fulfillment of the requirements for the degree of doctor of philosophy of Washington University.

studies upon the relative effects of the infra-red and ultra-violet wave-lengths.

In this review of literature, only those experiments which involve ultra-violet radiations will be summarized. It is both irrelevant and unnecessary to dwell upon the effects upon enzymes of other types of radiation: X-rays, radium emanations, etc.

Probably the first biologists to study the effects of light upon enzymes were Downes and Blunt ('79), who found that zymase was inactivated in quartz tubes by the full solar spectrum in the presence of oxygen; they concluded that the injurious effect was due chiefly to the blue-violet portion of the spectrum and that the inactivation process was an oxidation reaction. Fermi and Pernossi ('94), in a study of a number of environmental factors upon enzymes, found that pepsin and trypsin in aqueous solutions are attenuated by long exposure to sunlight, that diastase and ptyalin are but slightly injured by such exposure, and that bacteria exposed to sunlight lost considerable of their proteolytic activity. Green ('97) studied in great detail the action of sunlight and light from an electric arc upon diastase in leaves and in aqueous extracts; he found that both in the tissues and extracts the diastase suffered a considerable loss in activity, but that such injury did not occur when ultra-violet rays were removed by glass filters. In fact, when such filters were used, Green found that an increase in diastatic activity often occurred. He likewise showed that the proteins and perhaps the chlorophyll in leaf cells exert a protective influence for the enzymes against the abiotic ultra-violet rays. Emmerling ('01) contributed further to the study of the effects of sunlight upon enzymes; he found that invertase, maltase, lactase, amylase, and rennet suffered various degrees of attenuation, but that pepsin, trypsin, and emulsin were apparently unaffected. Von Tappeiner ('03) studied the effects of sunlight upon enzymes with and without the addition of fluorescing substances such as Magdala red, chinolin red, and eosin; he found in the case of diastase, invertase, and papayotin that little or no injury occurred when exposure was made without a fluorescing substance, but that when such a material was added, even in so dilute a concentration as 1:1,000,000, definite attenuation of enzyme activity resulted.

The Schmidt-Nielsens ('04, '08) exposed solutions of chymosin, chymosinogen, and antichymosin of blood serum for short periods to a carbon arc and found that in all cases an exposure of fifteen minutes was sufficient to produce as much as 95 per cent inactivation; when the ultra-violet spectrum was removed by filters no inactivation occurred, and they concluded that the ultra-violet rays were responsible for the damage. Jodlbauer and von Tappeiner ('06) exposed solutions of invertase to sunlight with and without the ultra-violet rays, and found that sunlight without ultra-violet was capable of producing a small amount of injury, which was increased to 80 per cent in ten minutes if a small amount of a fluorescing substance was added. The same authors later ('06a) rayed solutions of invertase with a carbon arc in a water bath to exclude infra-red radiations and found a definite injury when oxygen was present; from this, they concluded that the process was an oxidation reaction. Dreyer and Hanssen ('07) found that the radiations from a mercury vapor arc weakened the enzymes rennet, trypsin, and papayotin; they believed that the ultra-violet radiation was chiefly responsible for this injury, since a glass plate inserted between the arc and the enzymes prevented attenuation. The Schmidt-Nielsens ('08) rayed commercial solutions of rennet in a water bath beneath a mercury vapor arc and found a destruction of activity proportional to the length of irradiation, to the energy given off, and to the dilution, the greater dilutions of the enzyme suffering a greater degree of injury. With the use of special filters they determined that 93 per cent of the injury was attributable to the wave-lengths 200–250 mμ, 4 per cent to 250–313 mμ, and 3 per cent to the visible spectrum. They supposed the destruction process to be monomolecular and to be more or less independent of temperature.

Pougnet ('10) found that in the cumarin plant the characteristic odor is formed after irradiation. This process is dependent upon the activity of enzymes which were thus shown to be uninjured by the radiations. Pougnet ('11) found a similar condition in the production of odor in vanilla pods. Stassano and Lematte ('11) exposed suspensions of bacteria to a mercury vapor arc beneath a thin film of water to remove heat rays and found that

bacteria killed by such exposure produced agglutination which was only slightly less pronounced than that caused by living bacteria; hence they concluded that the inactivation of enzymes contributed little if any to the killing of bacteria by ultra-violet rays. Chauchard and Mazoué ('11) rayed solutions of malt amylase and yeast invertase with a quartz mercury vapor arc in separate and in mixed solutions and found that the amylase at the end of one hour's exposure was only 10 per cent as active as unrayed solutions, but that invertase had lost only 45 per cent of its activity. They concluded that it was possible to destroy amylase completely and have some active invertase left if a mixture of the two were rayed for a sufficient period of time. Agulhon ('12) studied the effects of radiations from a mercury arc upon sucrase, malt amylase, pancreatic amylase, pepsin, emulsin, and rennet, and reported that all of these enzymes suffered some degree of attenuation from wave-lengths shut out by glass but transmitted by quartz—in other words, the injury was caused by ultra-violet rays, with the visible rays contributing practically nothing to this effect. Burge ('17), in attempting to discover the mechanism by which ultra-violet rays kill protoplasm, found that such organisms as *Bacillus liquefaciens*, *B. prodigiosus*, etc., could be killed by ultra-violet rays without any apparent decrease in the power of their extracted enzymes to liquefy gelatin.

In 1923, Ludwig Pincussen, at the City Hospital of Urban, Berlin, began the publication of a series of papers entitled "Fermente und Licht," which reported a number of experiments conducted by him and his associates upon that subject. The first paper ('23) described the effects of sunlight and of a quartz mercury arc upon solutions of malt diastase as follows: 1. Sunlight had little or no effect upon the enzymes. 2. The mercury arc produced strong inactivation. In the summary of his paper, Pincussen mentions certain laws which seem characteristic of the action of abiotic radiations upon enzymes: "Die Wirkung des Lichtes auf die Malzdiastase ist äbhangig von der Verdünnung, von verschiedenen Begleitkörpern und vor allem von der Reaktion. Die grösste Lichtschädigung erfolgt bei einer Reaktion die als die optimale für die Fermentwirkung anzusehen ist. Es

scheint demnach, dass das Fermentmolekül bei seiner optimalen Wirkungsreaktion besonders labil gegenüber der Lichtenergie ist." Furthermore, Pincussen writes "Es scheint dass in gewissen Grenzen die Temperatur ohne Einfluss auf eine mögliche Lichtschädigung ist," thus omitting possible effects of the infra-red radiation from the arc upon the enzyme solutions.

Pincussen and Kato ('23) exposed solutions of soy-bean urease to sunlight and to the radiations from a quartz mercury arc and found that both strong sunlight and the arc radiations produced injury which was greatest at the optimum pH of the enzyme. Essentially the same results were found in a somewhat more extensive paper by Pincussen and Kato published later ('23a). Pincussen and di Renzo ('24) continued the work on diastase in various concentrations; they found that the injury produced by a mercury vapor arc decreased with increasing concentration of the enzyme in solution and that the inactivation reaction is monomolecular. Pincussen ('24) rayed malt and Taka-diastase and found the Taka-diastase somewhat more easily inactivated by ultra-violet than the malt-diastase. He discovered that when certain salts were added to the enzyme solutions, the degree of injury caused by the ultra-violet rays was noticeably decreased. He ('24a) continued his studies upon the protective action of salts and found that iodine salts particularly were instrumental in causing protection against ultra-violet rays. With Klissiunis ('24) he studied further the protective action of iodine salts, potassium and sodium iodides, and in addition the iodides of alkali earths, lithium iodide, rubidium iodide, etc., upon solutions of trypsin. They found that the addition of any of these salts decreased considerably the injury produced by light in the enzyme solutions. Pincussen and Seligsohn ('26) rayed solutions of blood catalase at 10 cm. from a mercury arc (with no protective measures against infra-red) and found that inactivation followed the laws for other enzymes: the proportionality of inactivation to dilution and optimum pH, and the protective action of salts, reported previously for diastase and trypsin. Pincussen ('26) reported additional experiments upon diastase, in which he described a "reactivation" effect in the case of purified malt diastase. When diastase solutions which had been injured in

varying degrees by exposure to a mercury arc were mixed with unrayed solutions, the mixtures showed greater diastatic activity than the sum of the activities of the separate solutions. This reactivation is the more intense the greater is the injury to the rayed solutions; when the injury is slight there is little or no reactivation; further, the reactivation is more striking the greater are the quantities of rayed diastase in the mixture.

Pincussen and Kumanomidoh ('28), in further work upon the addition of salts in relation to light inactivation, discovered a protective action of the chlorides of K, Ca, Mg, Li, and Pb. The order of protectivity varied with the different diastases used —salivary, malt, and Taka—and also with the concentrations of the salts and of the enzyme solutions. In general, the potassium salts seemed to offer the least protection, the calcium salts the greatest. Pincussen and Uehara ('28) rayed solutions of pepsin in a water bath with a mercury vapor arc and found definite inactivation which was greatest at pH 1.15, which is near the optimum for peptic activity. At pH 1.93 and pH 2.28 there was no significant difference between the activities of rayed and unrayed pepsin solutions. Pincussen and Hayashi ('28) used serum lipase from rabbits and guinea pigs, which was exposed at twenty centimeters from a mercury arc (again with no consideration of infra-red) and which suffered definite injury chiefly at acid pH values. When accompanying proteins were removed by precipitation with ammonium sulphate the injury was greater. The injury was practically nil at alkaline pH values. Pincussen and Kambayashi ('28) studied the effects of sensitizing agents, particularly eosin, upon the inactivation of Taka-diastase by ultraviolet and found that the addition of the agent in no case increased the degree of injury produced by a mercury arc, a result contradictory to earlier findings, and that with increasing concentration of the sensitizing agent there was a decrease in the amount of injury produced by light. In all cases the greatest inactivation occurred at the optimum pH, with or without the addition of the fluorescing agent. Pincussen and Oya ('29) studied the effects of light from a mercury arc upon Taka-diastase solutions in water baths at different temperatures. They found greater inactivation at higher temperatures (50° C.) than at

lower ones (16°). They found no reactivation phenomena. Pincussen and Oya ('29a) rayed solutions of Taka-diastase with a mercury arc and studied the lecithin-hydrolyzing power of the enzymes lecithase and phosphatase, which are invariably present in the diastase preparation under such treatment. They found a decrease in the activity of these two enzymes; the above-mentioned laws held true here again. They ('29b) found a great degree of inactivation of milk aldehydrase after an irradiation of one hour with a mercury vapor arc in the presence of oxygen. Pincussen and Roman ('30) found that the succinodehydrogenase of horse muscle was strongly injured in the pH region 6.0–8.0 by a fifteen-minute exposure to a quartz mercury arc; a lesser injury was produced by one hour's exposure to visible light.

Thompson and Hussey ('25–'26) rayed aqueous solutions of pepsin in a water bath above a mercury vapor arc and found definite inactivation of the enzyme. They concluded that the process was that of a monomolecular chemical change. They also decided, from that fact that .5 cm. of water separated the enzyme tubes from the arc, that "it would seem that the effective radiations are those in the ultra-violet region of the spectrum." In view of the fact that .5 cm. of water removes only a portion of the infra-red radiation, this assumption might be questioned.

Tauber ('30) found that exposure to direct sunlight does not injure urease; if, however, eosin is added, definite injury occurs. The radiations from a quartz mercury arc he found likewise to be inhibitory to the activity of urease; eosin increased the injurious effect. Thompson and Hussey ('31) rayed amylase solutions in a water bath with a mercury vapor arc and found inactivation which followed the course of a monomolecular radiochemical change and which they attributed solely to the ultra-violet wave-lengths in the arc spectrum. Pace ('31) studied the effects of radiations from a mercury arc upon solutions of trypsin and enterokinase which had been previously partially inactivated by heat; with irradiation, only further inactivation occurred; with visible light only, there was no further effect upon the enzymes. Pace made no provisions in his work for removing infra-red radiation.

Thus the uncontrolled features of these experiments, empha-

sized in an opening paragraph, are made obvious: (1) The failure to consider the energy output of the light source; (2) The neglect of the possibility of enzyme injury by infra-red radiation. As mentioned in the review of literature, a few experimenters have taken precautions for the removal of infra-red but in no work so far has a comparative study of the effects of ultra-violet and infra-red been completed; (3) The almost complete lack of study of the effects of ultra-violet radiation upon enzymes *in vivo;* too often the results of test-tube experiments have been utilized to explain the effects of radiations upon organisms without attempting to study the effects upon enzymes in tissues.

II. Statement of the Problem

It was the object of the experiments reported in this paper, first, to study the effects of radiations from a quartz mercury vapor arc upon two commonly used enzyme preparations, Taka-diastase and Difco invertase, with respect to the comparative effects of infra-red and ultra-violet portions of the spectrum upon them, with careful measurements of the energy output of the irradiation sources; second, to study the effects of the full ultra-violet spectrum, plus the visible spectrum, upon enzymes in plant tissues, with a view to determining whether or not the injury to these tissues is caused by injury to enzymes.

These two groups of experiments will be designated respectively as Series I and Series II.

III. Experimental Methods and Results

SERIES I

In this group of experiments, Taka-diastase and Difco invertase were used. In both cases, aqueous solutions of the enzymes were rayed in 2-mm. layers in open Petri dishes at 10 inches from a quartz mercury vapor arc, a Burdick lamp operated at 75 volts and 6 amperes. Experiments with infra-red rays present and with infra-red rays excluded were conducted in parallel. For the removal of the infra-red rays from the spectrum, a quartz water cell, consisting of a chamber with a 6-inch square of quartz 2 mm. thick for the bottom and a 1.5-cm. layer of water, was inserted midway between the arc and the enzyme solutions. Such a filter

removed the greater part of the infra-red radiation and transmitted without appreciable diminution of energy the ultra-violet wave-lengths. Hence, with the water cell in place it was possible to study the effects of the visible and ultra-violet spectra together, without the infra-red; since it has been conclusively demonstrated that the visible spectrum has a negligible effect upon enzymes, the results obtained with the water cell may be attributed exclusively to the ultra-violet rays. When the water cell is not inserted the combined effect of ultra-violet and of infra-red is obtained, from which by simple subtraction one can determine the extent to which infra-red produces injury and thus draw a comparison with the effects of ultra-violet alone, unless the combination of infra-red and ultra-violet produces a special effect.

Intensity measurements were made by means of a Leeds & Northrup type P reflecting galvanometer No. 2239 with a sensitivity of .7 microamperes, and two Cenco linear thermopiles arranged in parallel. A carbon filament incandescent lamp from the United States Bureau of Standards, standardized to give a radiation of 86.2×10^{-8} watts per sq. mm. of receiving surface at 2 meters when lighted at .4 amperes and 99.5 volts, was used as a basis for computing the radiant energy given off by the arc. The intensity measurements for Series I are as follows:

At a distance of 10 inches from the arc, with the quartz water cell in place: 5025.0×10^{-8} watts per sq. mm., or 1202.15×10^{-8} gm. calories per second per sq. mm. Without the water cell, at the same distance: $45{,}225.0 \times 10^{-8}$ watts per sq. mm. or $10{,}826.17 \times 10^{-8}$ gm. calories per second per sq. mm. It is evident that at this distance from the arc the energy falling upon a unit of area is composed of about 12 per cent ultra-violet and visible and about 88 per cent infra-red.

1. Taka-diastase.—Taka-diastase was rayed in .5 per cent aqueous solution in 10-cc. portions with and without the water cell before the arc, as described above. In all cases the period of exposure was 30 minutes. At the end of the irradiation period, distilled water was added to make the solutions up to 10 cc. to make up for evaporation during the irradiation. Then the activity of the rayed sets and of the unrayed (controls) was de-

termined by Appleman's ('11) modification of the Wohlgemuth ('08) iodine method for diastase, which is described below.

Three sets of 10 test-tubes each were arranged in test-tube racks and were designated *a*, *b*, and *c*, which referred respectively to the solutions unrayed, rayed with the water cell, and rayed without the water cell. In each set the tubes were numbered in units from 1 through 10. Ten cc. of a 2 per cent Lintner soluble starch solution were placed in each tube, and the 3 sets were immersed in an ice bath until the temperature of the starch solution in the tubes was the same as that of the bath; this was done to prevent enzyme action until all tubes were inoculated and could be set in the incubator. Then, in each set 1 cc. of the enzyme solution was placed in the tube numbered 10, .9 cc. in tube 9, .8 cc. in tube 8, and so on, down through tube 1, which received .1 cc. of the enzyme solution.

After the enzyme solutions had been added to the proper tubes the tubes were all set away in an incubator adjusted to 39° C., where they remained for 45 minutes. Following this incubation period, the tubes were again immersed in an ice bath until the temperature of the enzyme-substrate mixtures was the same as that of the bath, thus preventing further enzyme action. Then 2 cc. of the mixture were pipetted out from each tube into a glass vial bearing a number corresponding to that of the tube, 5 cc. of distilled water and 2 drops of iodine-potassium iodide solution (Meyer's) were added, and then color changes in the tubes in the 3 sets were noted. A yellow color indicated complete hydrolysis of starch; a reddish-yellow, a complete disappearance of starch but the presence of some dextrine; a red-violet, not quite complete disappearance of starch; and a definite violet color, the presence of considerable quantities of starch. The first tube in the descending series which showed a violet tinge was the index for comparing diastatic activity, since it represented the lowest limit of enzyme activity. The activity of the enzyme is expressed as the number of cc. of the starch solution which 1 cc. of the enzyme solution could hydrolyze during the incubation. For example, if tube 4, containing .4 cc. of enzyme solution, had the first tinge of violet in the descending series (that is, has practically entirely hydrolyzed the starch in that tube), then 1 cc. of

the enzyme solution under the same conditions would hydrolyze $\frac{1.0}{.4}$ or 2.5 times the same quantity of starch solution. If 10 cc. of starch solution is used as the substratum, then the quantity of solution which would be hydrolyzed by 1 cc. of the enzyme solution would be 10 × 2.5 or 25 cc. This figure is taken as the diastatic power of that enzyme under the specified conditions. The conditions and the diastatic power are usually expressed thus:

$$D \frac{T}{t} = N$$

wherein D is the diastatic power, T the temperature of incubation, t the duration of incubation and N the number of cc. of starch solution hydrolyzed by one cc. of the enzyme solution.

The Wohlgemuth method is perhaps not as fine as the copper method of measuring amyloclastic activity, but as Sherman, Kendall, and Clark ('10) write: "Although it is not quite as accurate as the gravimetric copper method, it is easier to perform and has the theoretical advantage of marking the completion of a fairly definite step in the digestive process, whereas the copper reduction method measures the amount of a substance or substances produced by successive steps through intermediate products which are but imperfectly known."

TABLE I

TAKA-DIASTASE

(T, 39°, t, 45 min.)

Experiment number	Set A Unrayed D	Set B Rayed with water cell D	Set C Rayed without water cell D
1	100.0	14.3	10.0
2	100.0	16.7	10.0
3	100.0	16.7	10.0
4	100.0	16.7	10.0
Average	100.0	16.1	10.0

The results of the Taka-diastase experiments are presented in table I.

From the table it is evident: (1). That considerable injury occurs in Taka-diastase with the water cell in place, and that such injury is caused by ultra-violet radiation; (2). That greater injury occurs when the water cell is removed; that is, the infra-red exerts an appreciable injurious effect in addition to that of the ultra-violet rays.

2. Difco invertase.—The Difco standardized invertase solution was diluted in equal parts with distilled water and then rayed in open Petri dishes under exactly the same conditions as those employed in the experiments upon Taka-diastase. The experimental sets were designated in the same way: A, the unrayed set; B, the set rayed with the water cell; C, the set rayed without the water cell.

After the irradiation, 20 cc. of the enzyme solution were added to 150 cc. of 20 per cent sucrose solution, previously adjusted to pH 4.6 with .1 N sodium acetate. The activity of the invertase solutions was determined by the polarimetric method as described by Waksman and Davison ('26). The rotation of each invertase-sucrose solution was determined immediately after the addition of the invertase and then from time to time thereafter to determine the time required to reach the end point. During this interval the solutions were kept in an incubator at 36° C. The periods of time required to bring the solutions to the same end point were taken as the indices of enzymatic activity (Waksman and Davison, '26, p. 177). The results of the invertase experiments are presented in table II. The table shows that the same

TABLE II

DIFCO INVERTASE

(t, time in minutes required to reach end point)

Experiment number	Set A Unrayed t	Set B Rayed with water cell t	Set C Rayed without water cell t
1	30.0	35.7	41.1
2	32.0	39.0	46.0
3	30.0	36.0	42.0
Average	30.66	36.90	43.03

results which obtained in the diastase experiments were evident here: there is definite injury caused by the ultra-violet radiation, which is significantly increased when the infra-red rays also are present to act upon the enzyme.

Expressing the value of the unrayed set average as 100, we find the values of sets B and C to be respectively 89.00 and 70.75.

SERIES II

The experiments described in this section were designed to study the effects of the ultra-violet radiations from a mercury vapor arc upon enzymes in plant tissues, with a view of obtaining information concerning the physiologic mechanism by which such radiations damage and kill vegetable tissues. The enzymes studied were amylase, invertase, peptase, and catalase. The plants used were "Bonny Best" tomatoes, red kidney field beans, and a strain of *Fusarium Lini* Bolley, kindly provided by Mr. W. E. Brentzel of the North Dakota Agricultural Experiment Station. As pointed out in the review of literature, the effects of ultra-violet rays upon enzymes *in vivo* have been studied in only two or three cases, and in those (with the exception of Green's work) the studies have been limited to the enzymes of bacteria. So far as the author is aware, this is the first paper in which studies of the effects of ultra-violet rays upon several enzymes in the tissues of multicellular plant forms are reported in detail.

A. BEANS AND TOMATOES

The bean and tomato plants were grown in individual 4-inch pots to a height of about 20 cm. when irradiation was begun. The plants were rayed 3 minutes daily for 7 days at a distance of 50 cm. from the arc. A quartz water cell containing 1.5 cm. of distilled water was placed a short distance below the arc to remove the infra-red rays from the radiations which reached the plants. Intensity measurements, made as described in Series I, showed 1256.25×10^{-8} watts per sq. mm. or 302×10^{-8} gm. calories per sq. mm. per second.

In both the beans and tomatoes the irradiation produced serious damage in the plants. The upper epidermises of the leaves were badly burned and the leaves showed the bronzing and

curling typical of ultra-violet injury. At the end of the 7-day period, the enzyme determinations were made. In all cases the measurements of activity were made on fresh tissue.

1. Amylase.—Ten gms. of fresh leaf tissue, after the removal of petioles, were ground with 10 gms. of quartz sand in a mortar for 3 minutes. Five cc. of distilled water were added to the mixture and the juice was pressed out through two layers of cheesecloth, after which it was centrifuged at 2000 r.p.m. for 4 minutes to remove solid materials from the supernatant liquid. The activity of the amylase in the juice was then determined by the Wohlgemuth method as described in Series I. One cc., .9 cc., .8 cc., and similarly descending quantities of the juice were placed in the properly marked test-tubes, each of which contained 10 cc. of chilled 1 per cent Lintner soluble starch solution. As a preservative, .5 cc. of toluol was added to each tube, after which the tubes were stoppered and set away in an incubator maintained at 39° C. It was found by preliminary trials that incubation periods of 6 hours for beans and 24 hours for the tomatoes were the optima. After the incubation the tubes were again chilled with ice and 2 cc. of liquid from each tube were pipetted off into vials marked to correspond with the test-tubes. Five cc. of distilled water and 2 drops of iodine solution were added to each vial, and color comparisons made. The results of the amylase experiments are presented in table III.

TABLE III

AMYLASE

(T, 39°; t, 6 (beans)—t, 24 (tomatoes))

Experiment number	Beans		Tomatoes	
	Unrayed D	Rayed D	Unrayed D	Rayed D
1	16.6	50.0	16.6	25.0
2	16.6	33.3	16.6	25.0
3	16.6	33.3	16.6	20.0
Average	16.6	38.8	16.6	23.3

Choosing 100 arbitrarily as the value of the activity of the amylase in the averages of the unrayed groups, we find the following comparisons:

Beans—Unrayed, 100.00; rayed, 258.40.
Tomatoes—Unrayed, 100.00; rayed, 155.37.

The figures show conclusively that there is a definite and significant increase in the amyloclastic activity of the juice of tomato and bean plants which have been badly injured by ultra-violet radiation.

2. Invertase.—In these experiments the plant juice was extracted and prepared in the same fashion as in the amylase experiments. The activity of the enzyme was determined by adding 5 cc. of the juice to 100 cc. of 15 per cent sucrose solution and incubating for 12 hours at 39° C. At the end of this period, 10 cc. of the mixture were added to 30 cc. of Fehling's solution which was just at the boiling point, and the mixture was allowed to boil for exactly 3 minutes. The tubes were then cooled and the cuprous oxide precipitate was determined quantitatively by titration with potassium permanganate as follows: The solutions were filtered and the residue of cuprous oxide was dissolved in Bertrand's solution (20 per cent sulphuric acid saturated with ferric sulphate), and this solution was then titrated with twentieth-normal potassium permanganate solution. The number of cc. of the permanganate solution required to give the copper-Bertrand solution a faint permanent violet tinge was taken as the index of enzyme activity.

In the invertase experiments, blank solutions were arranged which contained 5 cc. of the plant juice and 100 cc. of distilled water substituted for the sucrose solution. The copper in these solutions was determined just as in the solutions containing sucrose; in this way the quantity of invert sugars present in the plant extract was determined. This value was then subtracted from that obtained from the enzyme-sugar solution to give the actual amount of reducing sugars formed in the latter as a result of invertase activity.

The results of the invertase experiments are presented in table IV.

Using the value 100 as an expression of invertase activity in the averages of the unrayed sets, we find the activity in sets to be:

Beans—unrayed, 100.00; rayed, 124.29.
Tomatoes—unrayed, 100.00; rayed, 125.99.

TABLE IV

INVERTASE

(cc. of potassium permanganate)

Experiment number	Beans		Tomatoes	
	Unrayed	Rayed	Unrayed	Rayed
1	8.6	11.0	11.5	15.0
2	8.4	9.8	11.2	14.5
3	8.2	9.9	14.1	16.9
Average	8.4	10.23	12.26	15.46

Thus a distinct increase is demonstrated in the activity of invertase in the rayed plants.

3. Peptase.—The term "peptase" is used here as proposed by Fisher ('19) to include those enzymes whose activity is peptoclastic; the term is synonymous with the name "ereptase" proposed by Vines at an earlier date. The method of determining the activity of the peptase was that of Sorensen ('08) as reported by Fisher ('19), by means of which the degree of hydrolysis of the substratum is determined from the number of free hydroxyl groups formed.

The measurements of activity were made as follows:

Ten grams of fresh leaf material, without petioles, were ground vigorously with 10 g. of quartz sand in a mortar for 3 minutes, after which the mixture of pulp and sand was added to a solution of 5 gms. of Witte's peptone in 250 cc. of distilled water. The solution was covered with toluol as a preservative and placed in an incubator at 38° C. for 3 days. At the end of that time, the solutions were filtered rapidly through Buchner filters by vacuum, and the residue was washed with distilled water until the original solution and the washings made up a volume of 400 cc. Forty cc. of the filtrate were removed to a small flask and decolorized by shaking with 1 g. of alumina cream. After standing for 4 minutes, the solution was filtered and the residue washed in distilled water to make a volume of 65 cc. of filtrate. To this were added 15 cc. of a solution of thymolphthalein made up as follows: 50 cc. of 40 per cent formaldehyde, 25 cc. of absolute alcohol, and 10 cc. of thymolphthalein solution (.5 g. in 1000 cc. of 93 per cent alcohol).

The formaldehyde neutralized the free amino groups of the amino acids produced, forming methylene compounds; the carboxyl groups were then determined by titrating with fifth-normal barium hydroxide solution, the thymolphthalein acting as an indicator. The barium hydroxide solution was added to the decolorized filtrate until a distinct blue color developed.

It was necessary to apply corrections to compensate for the amino acids already present in the tissues and in the peptone. For this the tissue was ground as described above and added to 250 cc. of distilled water without peptone. After 3 days of incubation the determination was applied as above, the obtained value representing the relative amino acid content of the tissue. To determine the amino acids originally present in the peptone, a flask containing 250 cc. of 2 per cent peptone solution only was incubated for the usual period of time and then its amino acid content determined by the titration method. These two values—the amino acid content of the tissue and that of the peptone—were subtracted from those obtained from the tissue-peptone mixtures; the resultant figures represented the actual amount of amino acids formed as a result of the hydrolysis of the peptone by the peptase. The amount of the hydrolysis can be calculated as milligrams of nitrogen by multiplying the number of cc. of fifth normal barium hydroxide solution required to produce a blue color by 2.8. The results of the peptase experiments are shown in table v.

TABLE V

PEPTASE

(Milligrams of nitrogen liberated)

Experiment number	Beans		Tomatoes	
	Unrayed	Rayed	Unrayed	Rayed
1	165.0	198.6	103.6	140.0
2	176.4	201.6	123.2	148.4
3	182.0	207.2	112.0	134.4
Average	174.46	202.53	112.60	140.93

Expressed on the basis of 100 as the value of the controls, the following figures for the averages are obtained:

Beans—unrayed, 100.00; rayed, 115.44.
Tomatoes—unrayed, 100.00; rayed, 124.01.

Thus, the peptoclastic activity of the juice of tomato and bean plants which were damaged by ultra-violet rays seems consistently higher than that of unrayed plants.

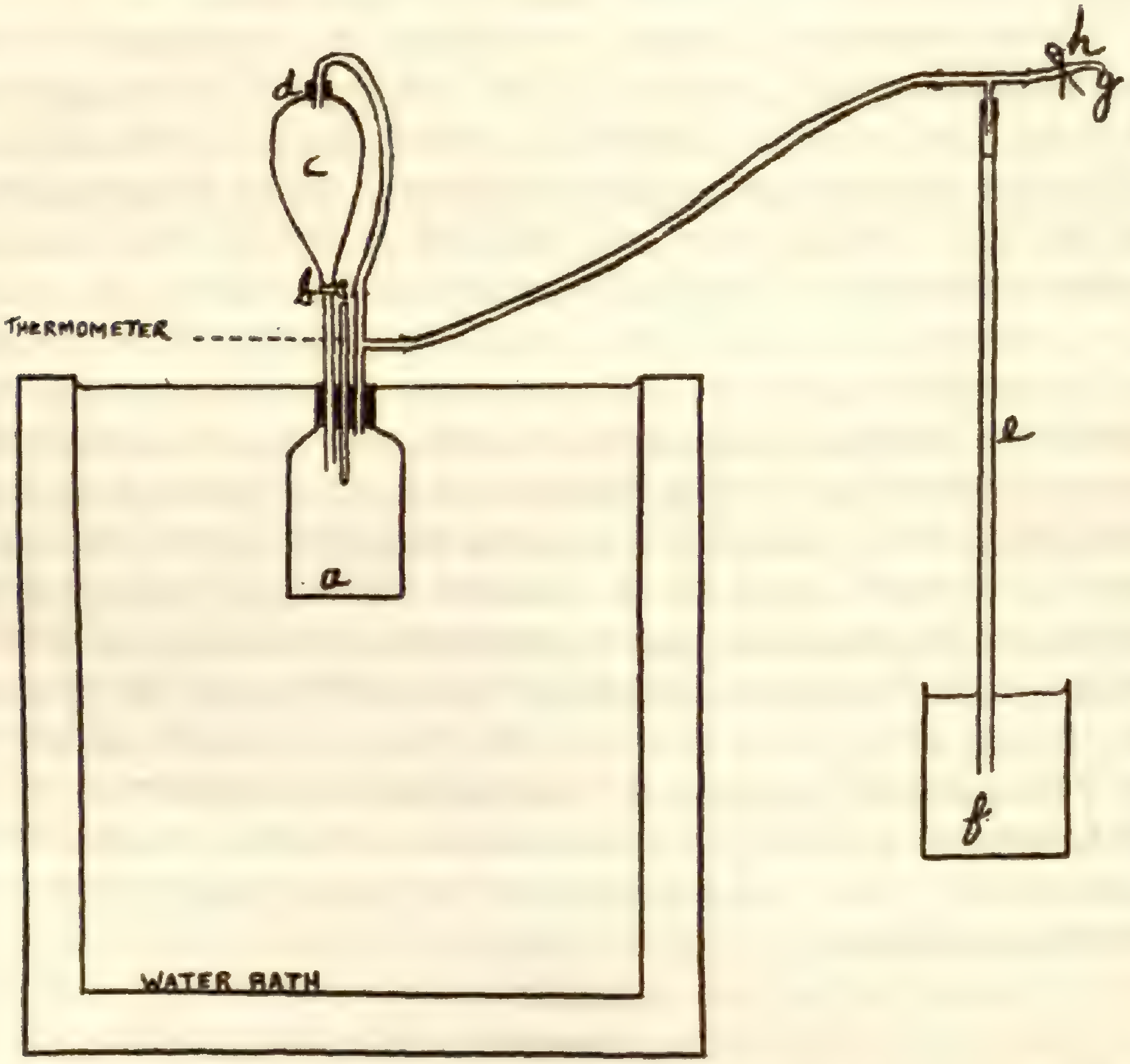

Fig. 1. Apparatus used in determining catalase activity: *a*, reaction bottle; *b*, stopcock; *c*, funnel; *d*, stopper; *e*, burette; *f*, water reservoir; *g*, rubber tube; *h*, stopcock.

4. Catalase.—The catalase activity of the juices of the rayed and unrayed plants was determined by the usual hydrogen peroxide method in a modified Appleman ('10) apparatus.[1] The apparatus used in these experiments differs from that devised by Appleman in that it has but one burette containing a column of water supported by atmospheric pressure on the open barometer

[1] The modified apparatus was devised by Mr. F. Lyle Wynd, of the Shaw School of Botany, and by the author.

principle as the volumeter, rather than the two burettes of liquid employed by Appleman. With this modification it is possible to make more accurate readings, since the oxygen released in the decomposition of the peroxide is released into a partial vacuum; it does not suffer compression as a result of having to displace the weight of a water column in addition to atmospheric pressure as is the case in the Appleman apparatus.

Seven grams of leaf tissue were ground for 1½ minutes in a chilled mortar with an equal weight of quartz sand and a little powdered calcium carbonate to neutralize the organic acids released by the crushing of the cells. The pulp was then pressed through two layers of cheese-cloth, and 1 cc. of the expressed juice was placed in the reaction bottle (*a*) of the apparatus, which had previously been immersed in a water bath kept constant at 19° C. Then 1 cc. of cold distilled water was added and the stopcock (*b*) closed. Six cc. of 3 per cent C. P. hydrogen peroxide were placed in the funnel (*c*), the stopper (*d*) tightly inserted in the top of the funnel and the water sucked up into the burette (*e*) from the water reservoir (*f*) by suction applied at the rubber tube (*g*). The tube (*g*) was then closed with a stopcock (*h*) and the funnel stopcock (*b*) was opened, allowing the peroxide to run into the reaction bottle (*a*). The evolution of oxygen began immediately, and the water column in the burette immediately began to fall. After the admission of the peroxide to the reaction bottle, the bottle was shaken vigorously and constantly by hand. The evolution of oxygen was allowed to proceed for 2½ minutes, at the end of which the total volume of gas evolved was read on the burette. All glassware, pipettes, mortars, etc. used in the work were chilled in an electric refrigerator before use, since it has been shown that catalase begins to decompose at temperatures slightly above 20° C.

The results of the catalase experiments upon beans and tomatoes are given in table VI.

With the values expressed on the basis of 100 for the unrayed averages, the following comparative figures result:

Beans—unrayed, 100.00; rayed, 143.18.

Tomatoes—unrayed, 100.00; rayed, 149.74.

The figures show that the activity of catalase in the rayed plants is definitely and considerably greater than that in the unrayed plants, a situation comparable to that obtaining in the case of other enzymes tested in these experiments.

TABLE VI
CATALASE
(Cc. of oxygen released)

Experiment number	Beans		Tomatoes	
	Unrayed	Rayed	Unrayed	Rayed
1	13.5	20.0	25.5	37.8
2	16.4	24.4	22.5	34.8
3	15.9	21.2	22.9	33.6
Average	15.26	21.86	23.63	35.4

B. FUSARIUM LINI BOLLEY

For the experiments with this fungus the following culture medium was used:

Magnesium sulphate	1 g.
Calcium phosphate (primary)	1 g.
Potassium nitrate	8 g.
Bacto-peptone	2 g.
Glucose	15 g.
Lintner soluble starch	5 g.
Distilled water	1000 cc.

The fungus was grown in 50 cc. of this medium in 150-cc. quartz flasks. After inoculation the flasks were kept in an incubator at 31° C. for 5 days, a sufficient period to produce a light film of mycelium on the surface of the culture fluid. After this the flasks were set at an angle of 45° in a horizontal rack and were rayed at 10 inches from the arc through a quartz water cell as described in Series I, the same intensity values obtaining in both cases. Exposure periods of varying length were employed in order to find the minimal time which would result in the death of the fungus. After these exposures, the cultures were allowed to remain untouched for an hour. Then transfers were made from them to fresh sterile culture solutions. As long as such transfers resulted in growth, it was obvious that the rayed mycelia were

alive. When, however, no growth appeared in the transfers, it was assumed that the mycelium had been killed by the irradiation. In these experiments, under the conditions mentioned above, an exposure of 12 minutes, with vigorous shaking of the rack at 3-minute intervals, was sufficient to kill the mycelium. After the irradiation the cultures were allowed to stand for an hour before the tissue was prepared for the enzyme tests.

The mycelium mats, torn apart by needles, were poured on to Buchner funnels, washed with several volumes of distilled water, and the excess water removed by pressing the tissue firmly between pieces of filter-paper. The mycelium was then placed in a quantity of 95 per cent alcohol 6 times its own volume and allowed to remain in it for 12 minutes, after which it was placed into a similar volume of acetone, in which it was kept for 8 minutes. Then it was placed in a second volume of acetone for 2 minutes, and after the removal from this bath, was spread out on filter-paper to dry at room temperature. The dried flakes of mycelium were then ground to a fine powder in a mortar. The powder was then placed in tightly stoppered bottles for storage. This powder was used for the determination of amylase and peptase activity.

1. Amylase.—Nine cc. of distilled water were added to 1 gram of the fungus powder in a test-tube, which was then placed in a refrigerator for 12 hours. The juice was then squeezed through double layers of cheese-cloth from the powder-water mixture and was tested by the Wohlgemuth method as described in Series I. The test-tubes containing the starch-enzyme mixtures were incubated for 24 hours at 39° C., after which the iodine test was applied. The results with the amylase experiments together with those of peptase are given in table VII.

2. Peptase.—The activity of peptase was determined by the Sorensen method as described elsewhere in this paper. One and one-half grams of the fungous powder were added to 250 cc. of the 2 per cent Witte's peptone solution in the rayed and unrayed sets, and the determinations made by the thymolphthalein method after an incubation period of 3 days. Blank solutions of powder only and of peptone only were tested as in the work on tomatoes and beans in order to determine the actual amount of amino

acids formed in hydrolysis. The results of the peptase experiments are shown in table VII.

TABLE VII

F. LINI

Experiment number	Amylase D		Peptase Mg. of N formed	
	Unrayed	Rayed	Unrayed	Rayed
1	14.3	16.7	112.7	121.0
2	14.3	16.7	104.1	110.6
3	14.3	14.3	100.2	106.8
Average	14.3	15.9	105.6	112.8

Expressed on the basis of 100 as the value of the averages of the unrayed groups the following numerical comparisons can be made:

Amylase—unrayed, 100.00; rayed, 111.09.
Peptase—unrayed, 100.00; rayed, 106.02.

Hence it seems that there is a slight but consistent increase in the activity of amylase and peptase in the irradiated fungi. The question may be advanced as to whether or not the increases are significant, since they are so small; if these apparent increases are not truly significant, the experiments show at least that the enzymes suffer no decrease in activity when the tissue is killed by ultra-violet rays.

III. Discussion

The inactivation of enzymes *in vitro* by ultra-violet rays has led to the supposition by some physiologists that the injury or death of tissues caused by such rays is attributable in part at least to this inactivation of enzymes. A few reports have been made upon the effects of ultra-violet rays upon enzymes in living plant tissue: those of Pougnet, Stassano and Lematte, Burge, and Green. In so far as the author has been able to determine, these are the only experiments which have investigated the effects of ultra-violet rays upon enzymes in plant tissues.

The results of the experiments reported in this paper which have involved the study of a greater number of enzymes in more

complex tissues agree with those of the above-mentioned earlier works in regard to this fact: namely, it is possible to produce advanced injury (beans and tomatoes) or death (*Fusarium Lini*) in plant tissues without injury to the enzymes contained by those tissues. From this work the assumption may be made that the injury or death of living protoplasm as a result of ultra-violet irradiation is to be ascribed to physiological disturbances other than the inactivation of enzymes.

The present work presents another interesting discovery: that in some cases the activity of enzymes in tissues injured or killed by ultra-violet rays is greater than that of enzymes in healthy, non-irradiated tissues. The possibility suggested itself that a difference in dry weight or in pH of the rayed and unrayed tissues might account for the difference in enzyme activities. Hence, a number of dry-weight and pH determinations of leaf tissue and extracts were made; the results are presented in table VIII.

TABLE VIII

DRY WEIGHT AND pH DETERMINATIONS

Sample no.	Beans				Tomatoes			
	Rayed		Unrayed		Rayed		Unrayed	
	% dry of wet wt.	pH	% dry of wet wt.	pH	% dry of wet wt.	pH	% dry of wet wt.	pH
1	12.0	5.80	12.4	5.80	12.3	6.18	10.3	6.18
2	13.0	5.75	10.1	5.80	11.5	6.18	11.5	6.10
3	12.1	5.81	11.4	5.65	13.2	6.20	12.1	6.18
4	12.2	5.80	10.2	5.85	11.9	6.18	10.7	6.18
5	10.7	5.80	11.8	5.80	12.1	6.10	11.6	6.15
6	11.6		10.9		11.4		10.8	
7	11.4		11.2		10.3		10.1	
8	12.1		11.7		13.5		11.2	
9	11.2		10.1		11.9		10.4	
10	11.0		10.8		12.3		12.0	
Av.	11.83	5.79	10.06	5.78	12.04	6.16	11.07	6.15

The table shows a slightly greater dry weight in the rayed sets both in the cases of the tomatoes and beans. The differences, however, are so small that the increased activity of the enzymes

in the rayed sets can hardly be explained on this basis. The results of the pH determinations show agreement with those of Eltinge ('28), who found no pH differences among rayed and unrayed plants. On the basis of these measurements, then, it must be concluded that the increased enzyme activity is not a result of differences in dry weight or in the pH of tissue extracts.

It was suggested that there might be other secondary ways in which the radiations could have induced such differences in enzyme activity. It is known that in various types of injury to tissues the activity of enzymes, particularly of respiratory enzymes and catalase, is increased. The accelerated activities obtained in these experiments may be such a reaction—merely a stimulation due to tissue injury and not at all a specific reaction to ultra-violet rays. Such an explanation, however, would hardly account for the enormous stimulation obtained in some cases, for example, bean amylase, in which the activity in the rayed tissue is more than 2½ times that in the controls. In such cases, something akin to Pincussen's ('26) reactivation phenomenon may occur. A portion of the enzyme in the tissue may be in a more sensitive condition than another portion and may suffer partial or complete inactivation as a result of irradiation, whereas the second portion may be completely protected by cell proteins, chlorophyll, etc. against the lethal rays. The injured enzyme substance may then through subsequent contact with the uninjured portion experience the reactivation as described by Pincussen in his *in vitro* experiments. Pincussen found that when such unrayed and rayed enzyme solutions were brought together, their combined activity was considerably greater than the summation of their separate activities. Such a phenomenon may account in large degree for the results of the present experiments.

Another suggestion which might be made in regard to the stimulation of enzyme activity concerns the relations between the enzymes and their coenzymes. It might happen that the enzyme itself suffers partial inactivation by the ultra-violet rays and thus leaves an excess of coenzyme. This excess of coenzyme then stimulates the remainder of the actual enzyme to greater activity.

The experiments upon Taka-diastase and Difco invertase illustrate a point made by the author in an earlier paper (Fuller,

'32), in which it was shown that at short distances from a quartz mercury vapor arc the infra-red radiation was responsible in considerable degree for injury previously attributed to ultra-violet radiation. The present experiments upon enzymes *in vitro* demonstrate that infra-red radiation causes a significant proportion of the injury to enzymes rayed in close proximity to a mercury arc, a factor which has been neglected in most of the earlier experiments.

IV. Summary

1. When solutions of Taka-diastase and Difco invertase are irradiated *in vitro* by a mercury vapor arc, the enzymes suffer partial inactivation. This injury is due in part to ultra-violet, in part to infra-red radiations.

2. When bean and tomato plants are severely injured by ultra-violet rays, the activity of their amylase, invertase, peptase, and catalase is significantly increased.

3. When mycelium of *Fusarium Lini* Bolley is killed by ultra-violet rays, there is no decrease in the activity of its amylase and peptase. There is some evidence for a slight increase in the activity of these enzymes.

4. Confirmation is given earlier evidence that the death of living tissue as a result of ultra-violet irradiation is attributable to some factor other than the inactivation of enzymes, and additional data are presented to emphasize those earlier findings.

V. Acknowledgments

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